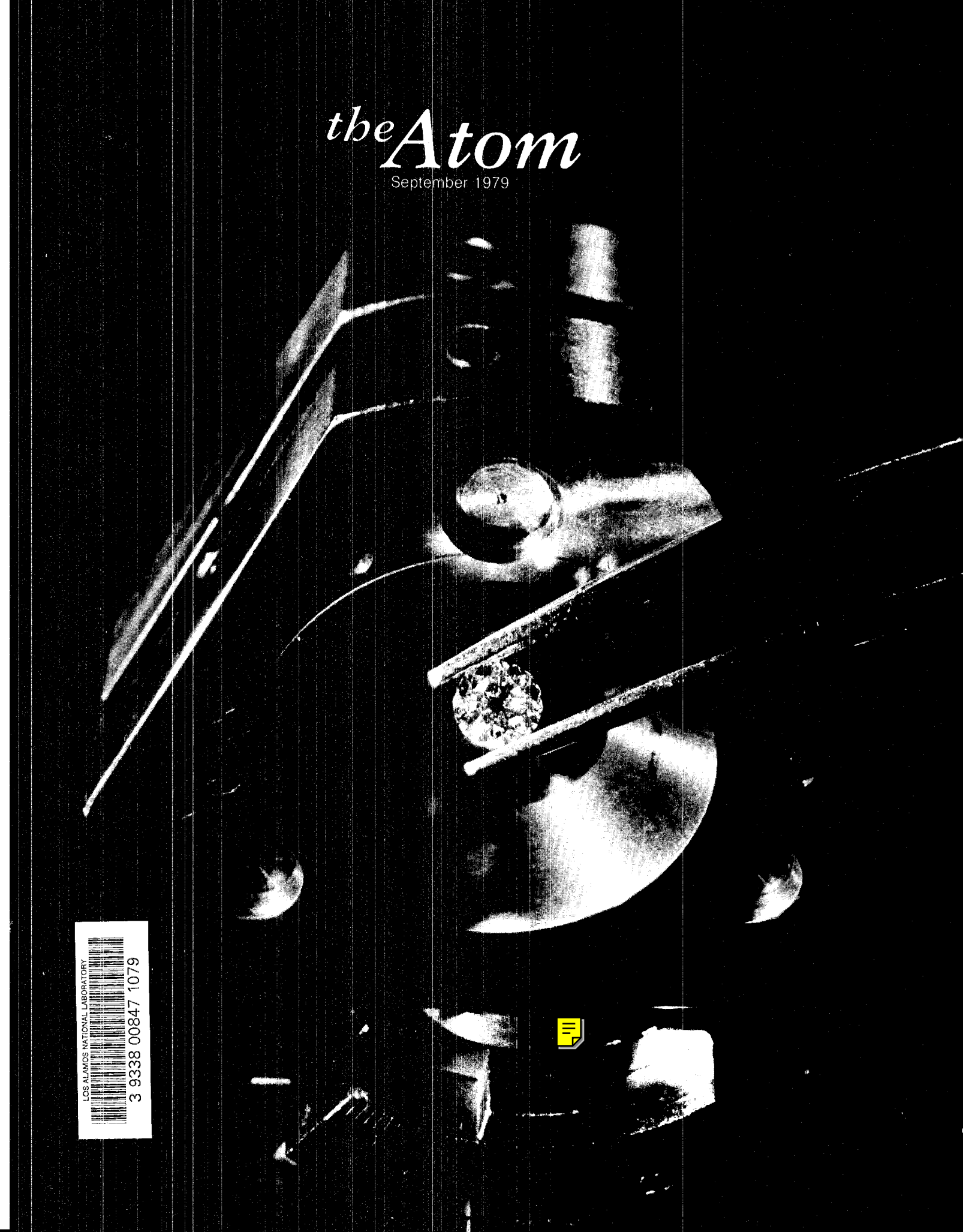
the Atom

September 1979



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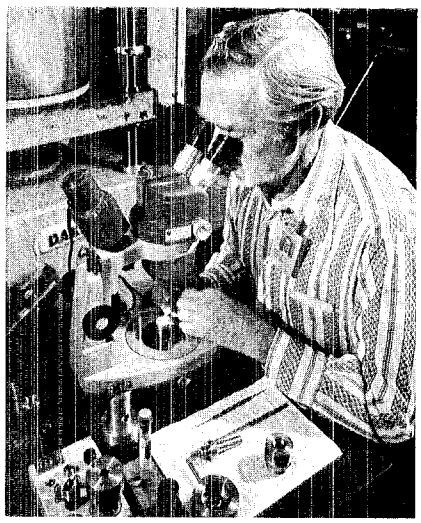
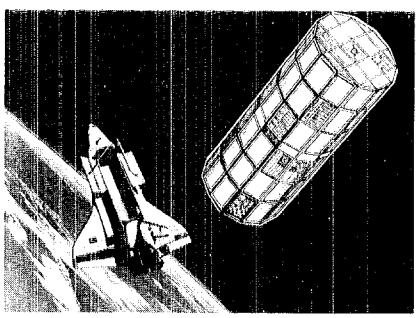
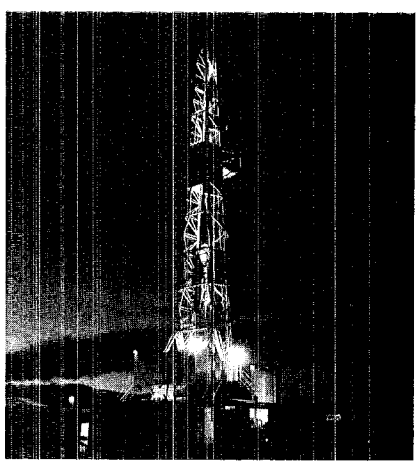
ON THE COVER:

Tweezers hold a 0.3 karat industrial diamond in front of a completely assembled Merrill-Bassett diamond anvil cell. Other photos by Henry Johnson, and a story by John Armistead on a special way to compress materials, can be found in this issue.







Preview:

Diamonds are valued by most people for their brilliance, emotional connnection, or investment value. At Group M-1, diamonds are prized for their properties of hardness and transparency. They are useful in pressure cells to study the changing faces of materials. Forces of up to 10 tons are applied to the diamonds to generate the high pressures required, John Armistead writes...

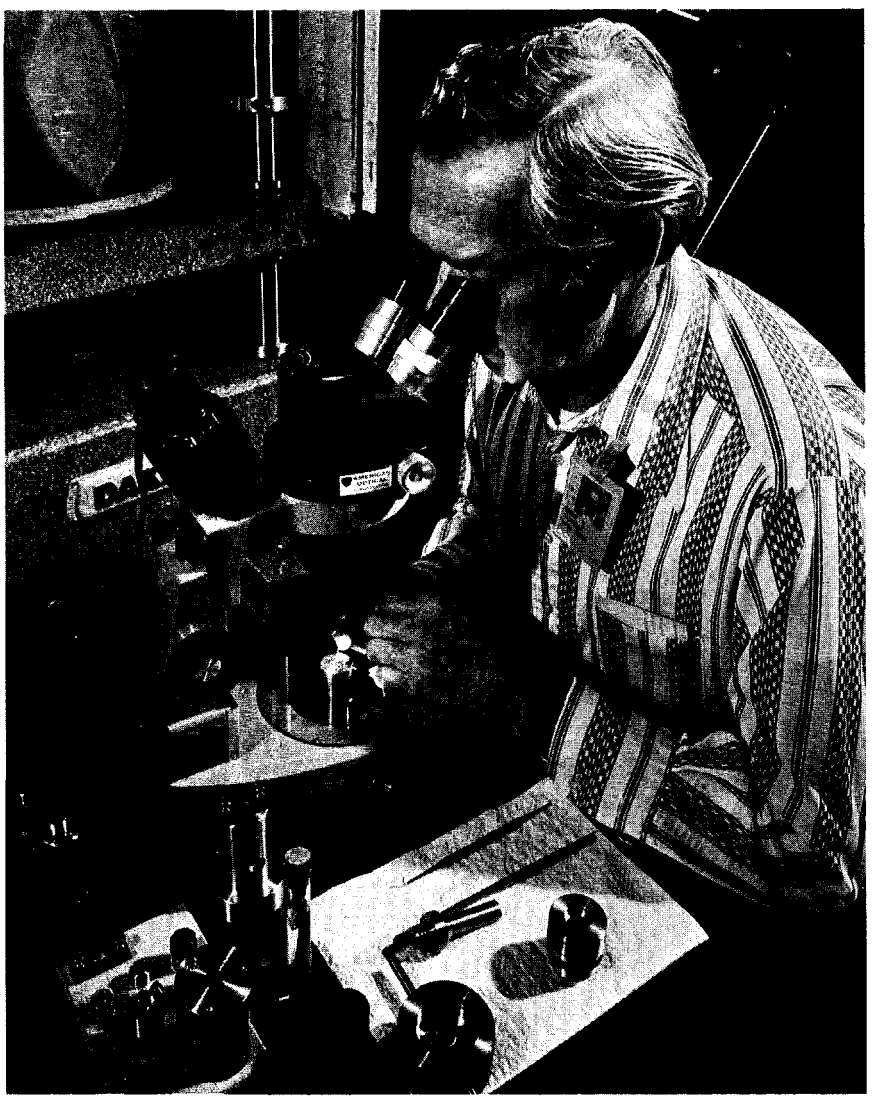
America's Space Shuttle program will include a "cold bird" to carry a variety of experiments. The bird, scheduled for launch in late 1981 or early 1982, will be carrying at least one LASL experiment from Group Q-15. It will also carry a small experiment from Chamisa Elementary School. When 6 to 9 months have elapsed, the bird will be retrieved from its space orbit and brought back...

The Department of Energy has urged LASL to cut its use of natural gas back drastically in the next few decades, and to look for alternative fuel sources. Since Los Alamos has pioneered some geothermal breakthroughs at the Fenton Hill site by drilling into hot dry rock, it is now trying to practice what it has been preaching and drilling proceeds for an exploratory hole on Sigma Mesa. The hopes are to find either hot water or hot dry rock, and the costs are less than for alternatives such as coal or nuclear power...

Diamond cells aid in measuring extreme pressure

Tweezers hold a 0.3 karat diamond in front of a pressure cell.

Photos by Henry Johnson



Correct alignment of diamonds is critical to successful high pressure work. Here, Leroy C. Schmidt of SD-5 examines the positions of diamond anvils on cell supports.

By John Armistead

Diamonds. They are forever, an advertisement says. They are hailed as a girl's best friend.

To Dave Schiferl and Larry Schwalbe in Group M-1 and a select few Laboratory researchers in other divisions, diamonds are an ingredient in experiments to try to create and measure pressure almost half that in the center of the earth.

Schiferl and his coworkers have experimented so far with pressures up to half a megabar. For reference, the pressure at the earth's center is 3.5 megabars; a megabar is a million atmospheres.

And why the extreme pressure? The properties of materials can change drastically under pressure. Nitrogen gas changes to a solid able to support greater shear stresses than the best steels. Bromine, which is normally a poisonous liquid, changes first to a semiconductor and then to a metal. Understanding these changes helps us know more of the basic properties of matter.

When LASL researchers want to compress small amounts of a solid, liquid, or gas, there is no need to use an enormous press weighing many tons. The diamond-anvil pressure cell, relatively inexpensive and very compact at several inches in length, permits the study of substances' properties by compressing the material between the points of two small diamonds.

Pressure is simply force per unit area, and very high pressures can be created by greatly increasing the force on a material or decreasing the sample size. The diamond cell relies on the latter principle.

Diamond tips

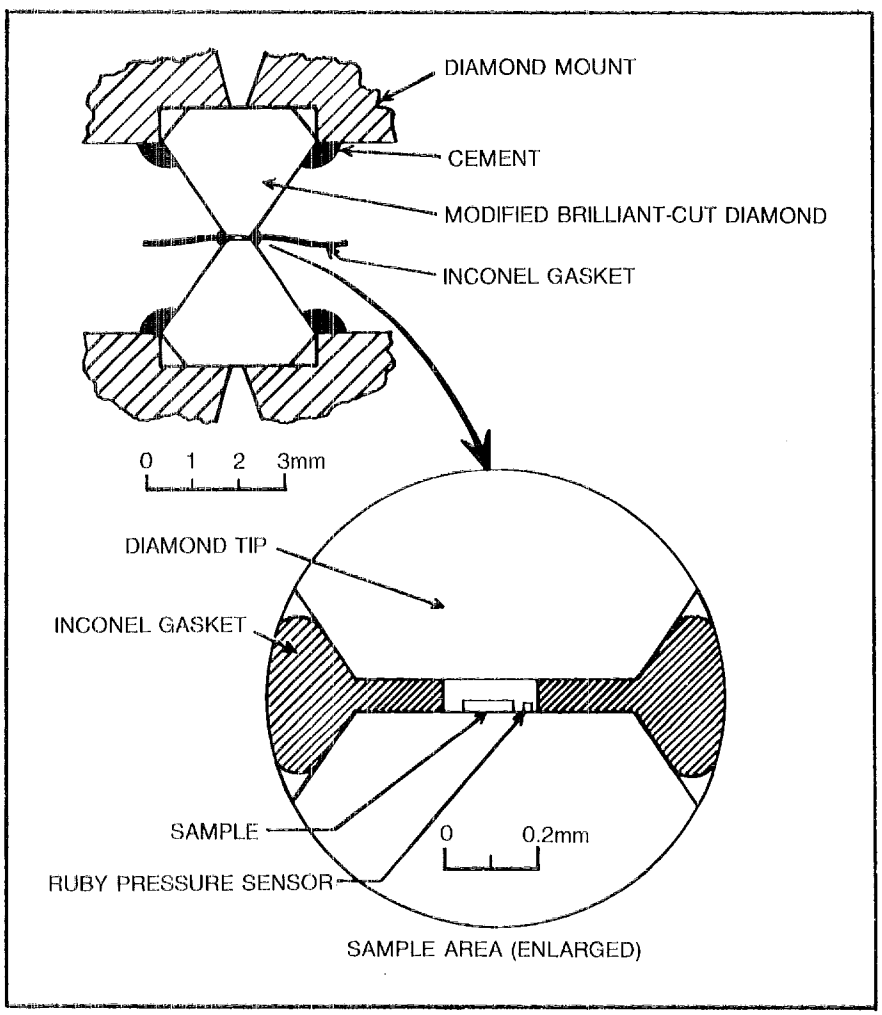
The diamond anvils are made from gem-quality, brilliant-cut diamonds which have the culet tips polished down to a flat surface 0.6 mm in diameter. A gasket of Inconel initially 0.2 mm thick is indented by these diamond tips until the thickness between the diamonds is only 50 microns. (A micron is a millionth of a meter, contrary to what the producers of "Battlestar Galactica" are trying to foist on us.)

A hole 0.2 mm across is drilled in the center of this indentation and is filled with the pressure medium, the sample, and a small chip of ruby that is used to measure the pressure. Loading a diamond cell requires a 60X microscope and a watchmaker's patience.

Forces up to 10 tons are applied to the diamonds to generate the high pressures, but the samples are not crushed. The tremendous pressures are applied with great precision.

"We often apply 100 kbar (about 700 tons per square inch) to a delicate sample," said Schiferl, "and bring it back down to ambient pressure after our experiments in such a way that the sample has returned exactly to its original condition — even on a submicroscopic level." The high precision allows LASL researchers to routinely make high-pressure measurements with

The pressure cell compresses material between the points of 2 small diamonds; they are transparent to light, x rays, gamma rays, and wide ranges of the infrared and ultraviolet spectra.



This diagram shows the location of the diamonds and the ruby crystal in the pressure cell.

an accuracy undreamed of a decade ago.

Why are diamonds used for the anvils?

They withstand greater pressures than any other known material, and they are transparent to light, x rays, gamma rays, and wide ranges of the infrared and ultraviolet spectra.

The kinds of sample properties that can be observed in diamond cells include: material compressibility; phase transitions such as freezing and changes in crystal structure; changes in magnetization — the onset of superconductivity; changes in the radioactive decay rate of K-capture isotopes; chemical changes; estimates of shear strength; changes in dielectric properties; and lattice dynamics.

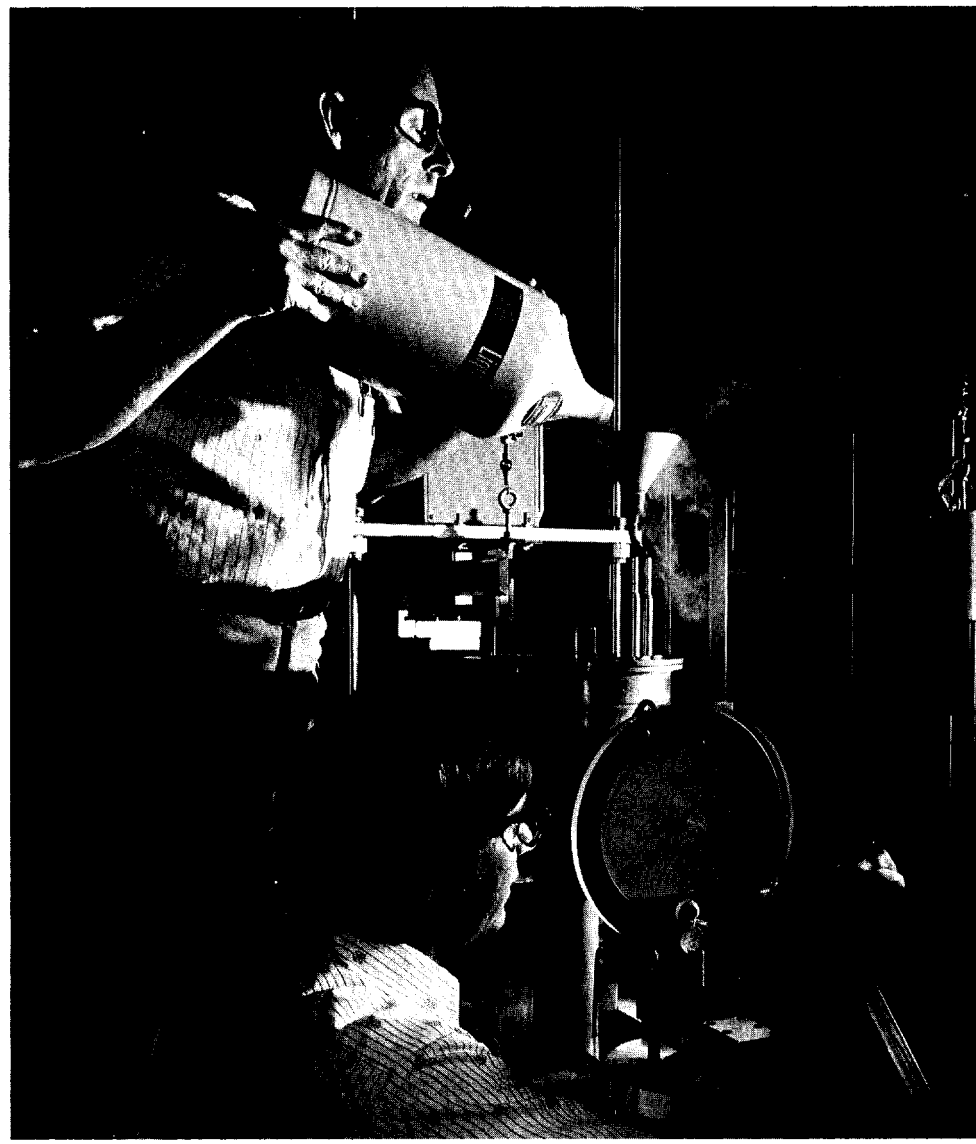
A major problem is measuring high pressure. While the definition of pressure as force over area seems simple enough, using this in a real pressure system which has uneven stress distributions, and in which some of the applied force is counterbalanced by frictional forces, has proven extremely difficult.

Measurement by ruby

In diamond cells, small chips of synthetic ruby are used to gauge the pressure on the sample. The ruby chips fluoresce bright red when illuminated with green or blue light from a laser. The wavelength of the red fluorescence light increases with pressure. About 7 years ago, the National Bureau of Standards calibrated this shift against primary pressure scales established through shock wave research in which LASL's explosives studies played a leading role.

LASL has a large variety of diamond-anvil cells, the most expensive costing about $7,000. Interestingly, most of the cost is in the demanding machine work, not the diamonds themselves.

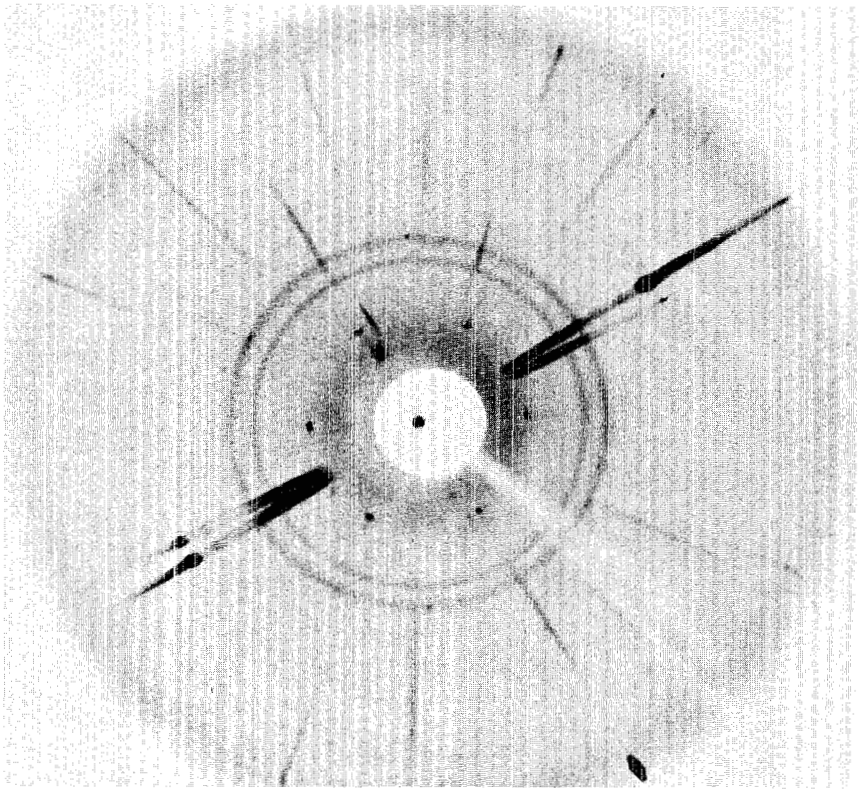
"We utilize a lot of off-the-shelf technology from the National Bureau of Standards, which was the primary organization to develop it into a reliable research tool, and from the Carnegie Institution Geophysical Laboratory, which holds the world's static pressure record of



Bob Mills, left, and Don Liebenberg, right, both Q-10, work with apparatus designed for high pressure studies on hydrogen and helium. Mills topped off the level of liquid nitrogen in the cryostat, while Liebenberg applied pressure to the diamond anvil cell inside.

Nitrogen gas changes to a solid with greater shear tolerances than the best steels. Bromine, normally a poisonous liquid, changes first to a semiconductor and then to a metal.

David Schiferl, left, M-1, and Don Cromer, right, CMB-5, align a diamond anvil cell on the single crystal x-ray diffractometer at CMB-5. The cell can be positioned in exactly the right place to perform precision crystallography at very high pressures.



Chips of synthetic ruby fluoresce bright red under laser light and are used to gauge pressure on a sample.

1.72 megabars," said Schiferl.

He also noted that LASL is a "great place for scrounging equipment" to set up experiments he is pursuing. "We actually have invested surprisingly little money to do all the research we do. We have scrounged lasers, x-ray equipment, spectrometers, pressure cells, and lots of other equipment. And it's all good, too — nothing but the best."

Portable tools

Because diamond cells are small and very portable, they can usually be carried to existing apparatus for measurements. Close cooperation between divisions and groups has made it more convenient to use existing facilities, rather than to set up a special high-pressure laboratory at great expense.

Said Schwalbe, "We have loaded samples at P-10, then measured pressure at M-1, done x-ray diffraction studies at CMB-5, and Raman and infrared spectroscopy at CNC-4.

Diamond cells were only sporadically used at LASL until about 2 years ago. A concerted effort to measure with them has resulted in LASL becoming a leading laboratory in diamond cell pressure work. LASL pioneered experimental techniques for studying condensed gases, techniques that are now routinely used around the world. LASL is also unsurpassed in static high pressure studies on actinide elements.

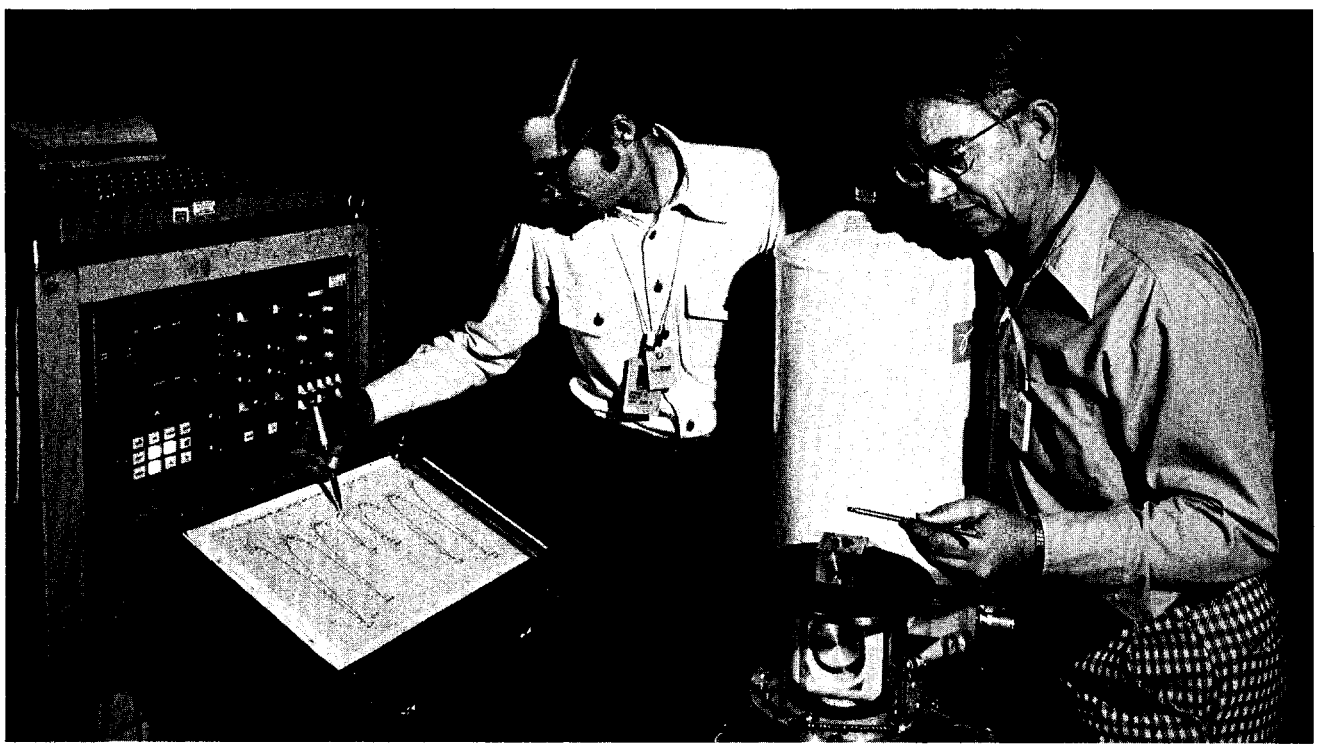
X-ray film captured the image of a diffraction pattern of a single crystal of nitrogen under pressure. At the time of the experiment in early 1978, the pressure of 25 kilobars was a record.

"The diamond cell is an ideal device to study the pressure behavior of transuranic elements," said Shiferl, "because only minute amounts of these exotic substances are required. Typically, this is 50 micrograms, about the weight of a grain of salt."

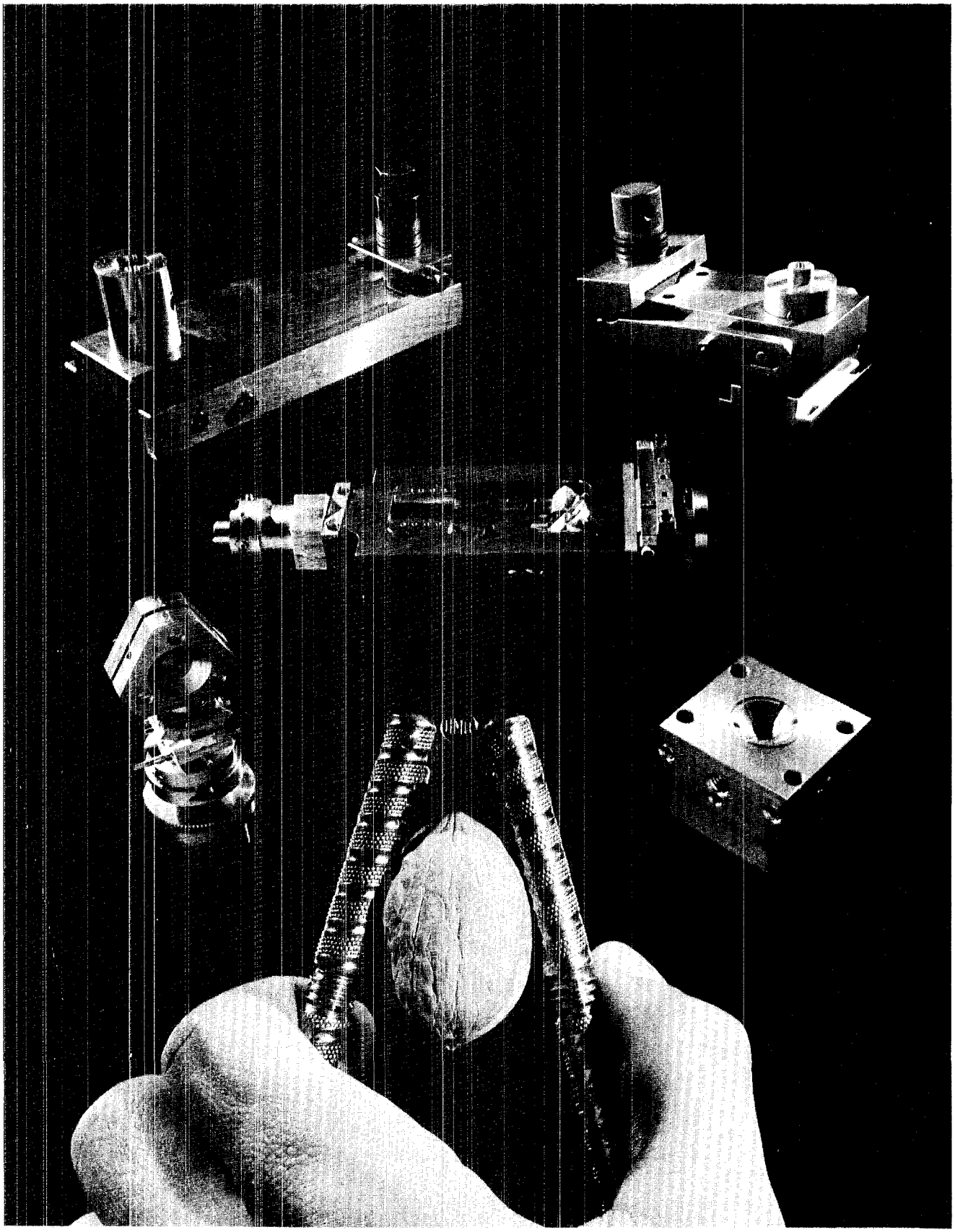
One of LASL's most important contributions to diamond cell development may be in the first systematic effort to apply nondestructive testing methods to improve diamond cell performance. X-ray fluorescence is used to check alloy composition before the parts are machined. Magnafluxing allows small cracks and distortions in the cell components to be detected.

"We are trying out a suggestion of Len Trimmer, M-1, to use acoustic emission equipment to detect the first subaudible cracks that occur just before massive failure. The first tests are very encouraging," said Schwalbe.

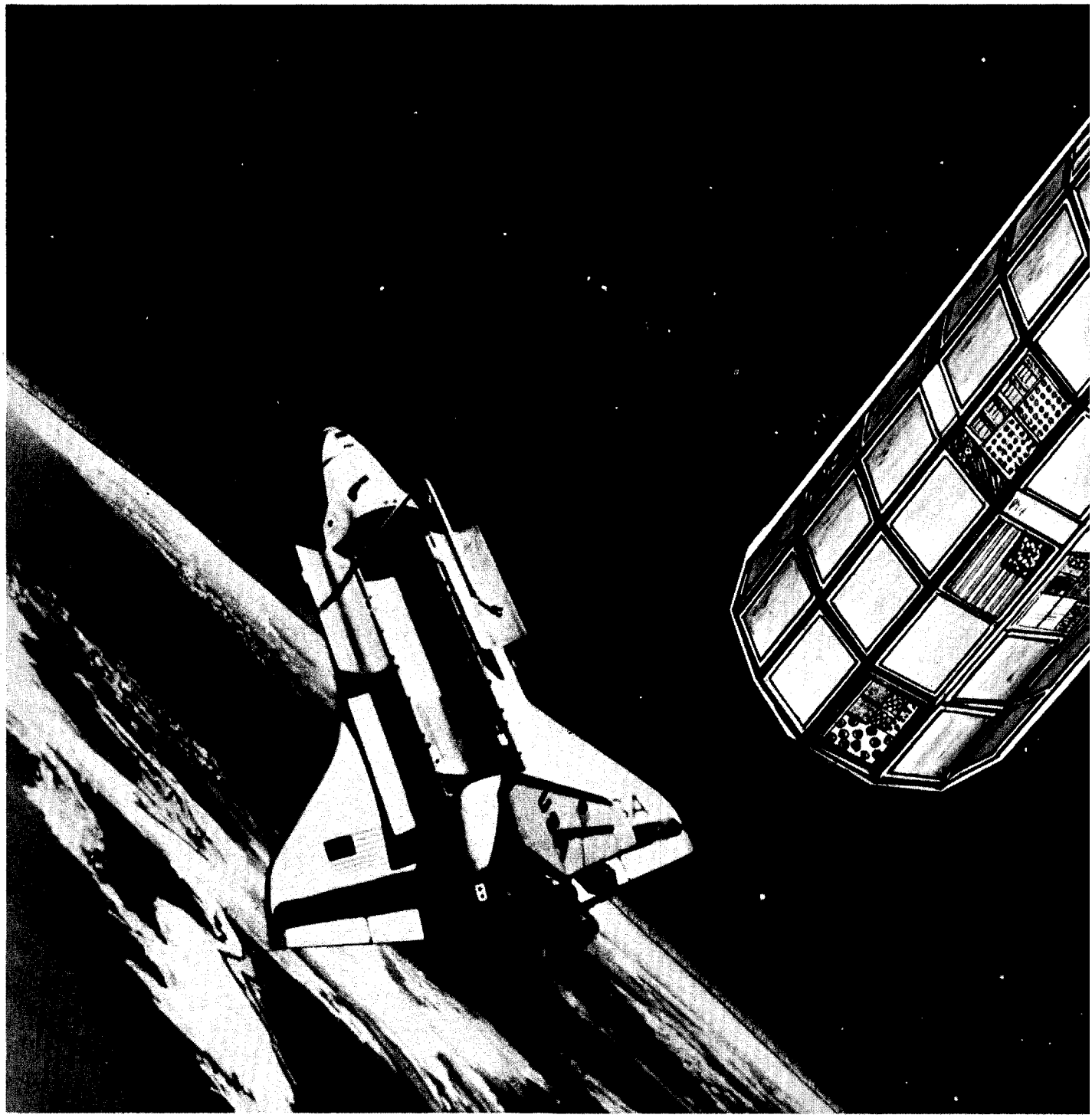
Leroy C. Schmidt, left, SD-5, and Bob Mills, right, Q-10, discuss construction of the gas loading system for a diamond anvil cell.



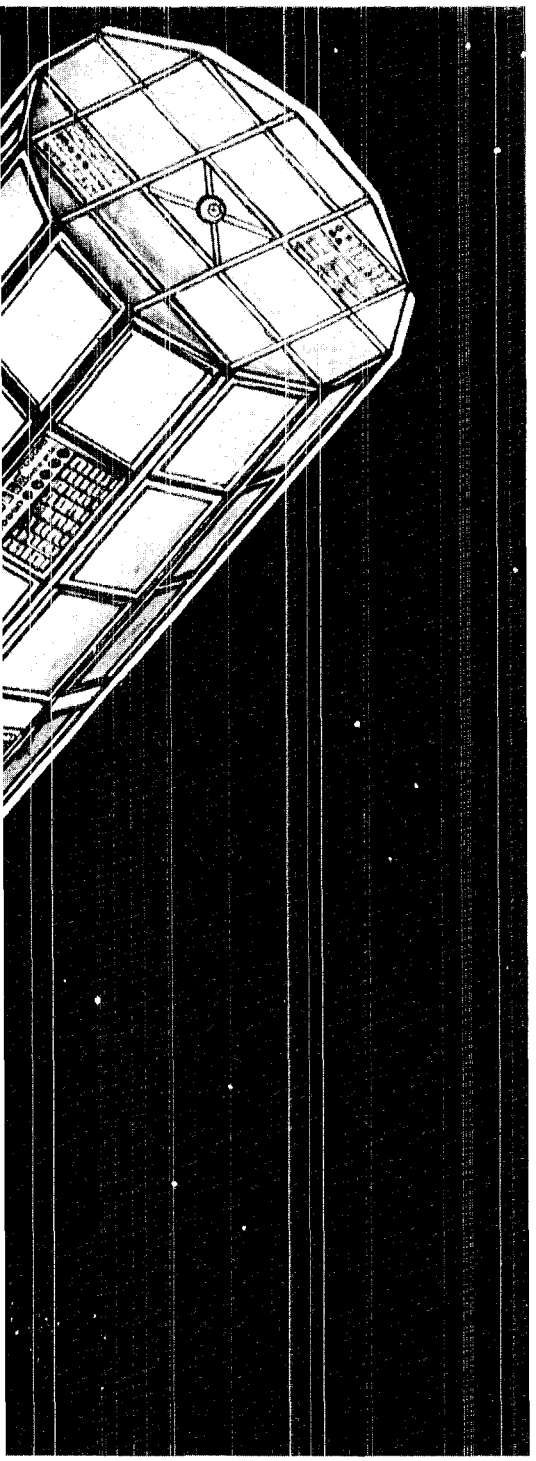
Jeff Willis, left, and R. Dean Taylor, right, both of Group Q-10, perform Mossbauer spectroscopy on iron, which becomes non-magnetic at 130 kilobars. With this technique, they can test the chemical bonding of certain elements in the sample.



A selecton of 5 diamond anvil cells and a close relative, clockwise from lower left: Merrill-Bassett, Mao-Bell, Piermarini-Block (NBS), Bassett. Center: Schiferl-Jamieson-Lenko.



Experiments in 86 trays will be separated from Earth communications until another Space Shuttle retrieves the facility, 6 to 9 months later, and brings it back for analyses.



Into space on a 'cold bird'

By Jeff Pederson

Eight years ago, the National Aeronautics and Space Administration (NASA) began to develop an orbiting satellite to serve as a test station to investigate meteoroid damage that could be encountered in space. Today, this program has evolved into the Long Duration Exposure Facility (LDEF in shorthand), which has a different scope, and is being offered to scientists as a way to obtain low-cost space experiments for a variety of investigations.

NASA hopes to orbit this craft from the Space Shuttle above earth in late 1981 or early 1982. The free-flying facility will be a "cold bird," in the words of Lenwood Clark, of the LDEF project office. Earth scientists, he explained, wouldn't have contact with LDEF until another Space Shuttle flight retrieves it and brings it back home some 6 to 9 months later.

In the event power supplies are needed, many experiments, including some proposed in Los Alamos, could be operated either by solar cells or batteries. Other tests in the 86 experiment trays available would be passive, where materials or scientific components would later be checked for their ability to withstand the rigors of the space environment.

Clark and William Kinard, both from the Langley Research Center in Virginia, gave a recent briefing on the NASA facility to a group of Los Alamos researchers. They had been invited here by Maj. Joseph Angelo, who is an Air Force officer with the Defense Nuclear Agency's LASL Liaison Office, and who also is a man with an extensive background and experience in the field of space exploration and research.

The Los Alamos concepts advanced to NASA for flight experiments on the "cold bird" include a proposal by Karl L. Meier, Group Q-15, for testing several space reactor components. In addition, students from Chamisa Elementary School will be flying "Project Space Garden," which is designed to test the effect of the space environment on seeds.

Before discussing these in detail, however, it may be illuminating to further treat the LDEF facility itself and America's Space Shuttle program.

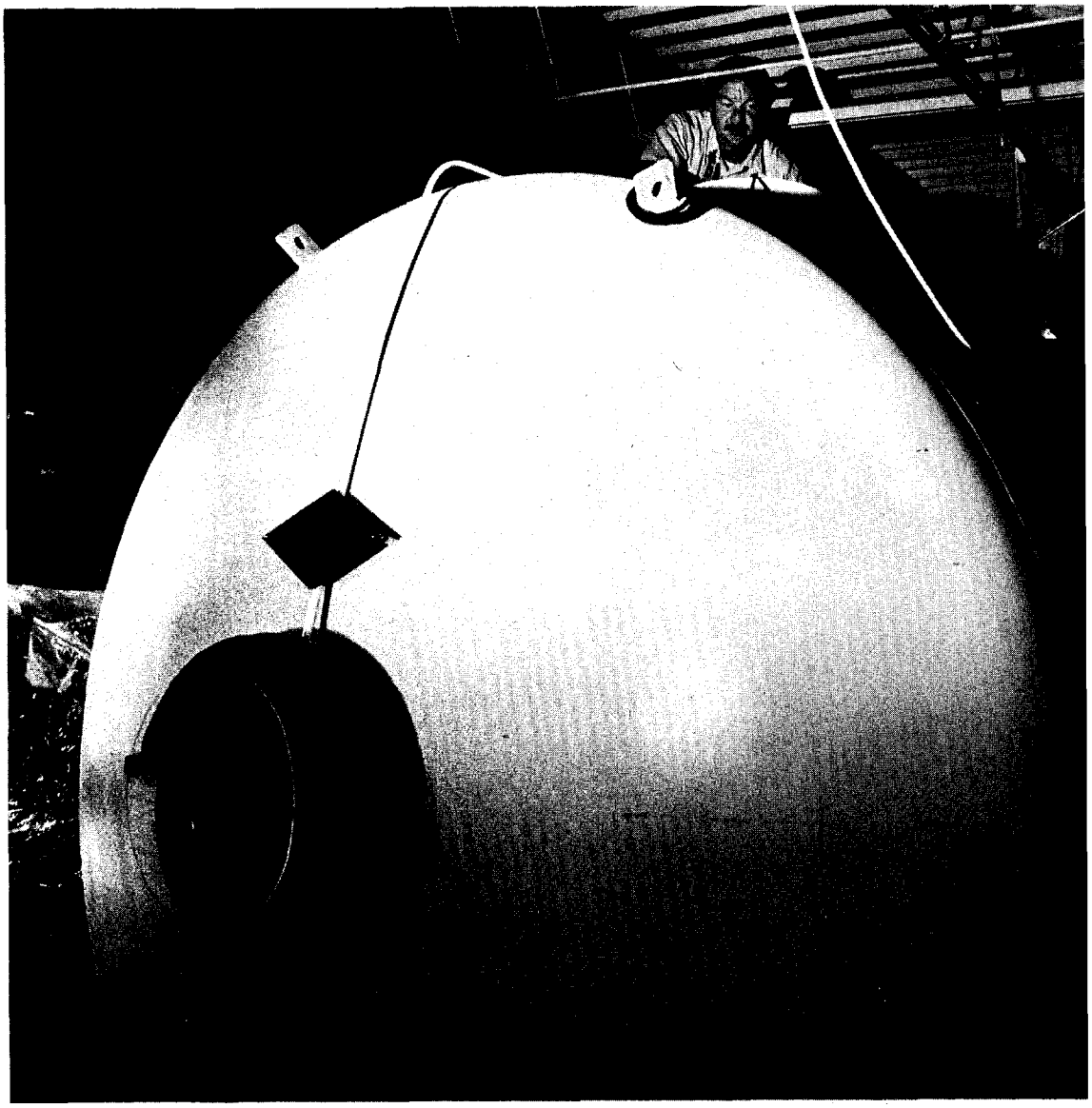
An artist's conception shows the Space Shuttle above Earth, at left, with the deployed Long Duration Exposure Facility, at right. Los Alamos projects will be among the dozens of experiments on board.

Photos by Bill Jack Rodgers

Into the 21st century

When he introduced a bill calling for a National Space and Aeronautics Policy Act, Sen. Harrison "Jack" Schmitt (R-NM) called for a program that would carry "this country and elements of our civilization into space and into the 21st century." Schmitt, a former Apollo astronaut, said a space program should deal with the building of a worldwide satellite systems in communications, weather forecasting, and earth resource sensing. If we can do so, he continued, "the benefits of the high technology of space will be available to... those developing countries... without the need to invest alone in its creation."

Permanent facilities in orbit could help create new export commodities and energy supplies in the next 3 decades of space activity, said Schmitt in the Congressonal Record this year. The Space Shuttle concept, the world's first reusable space



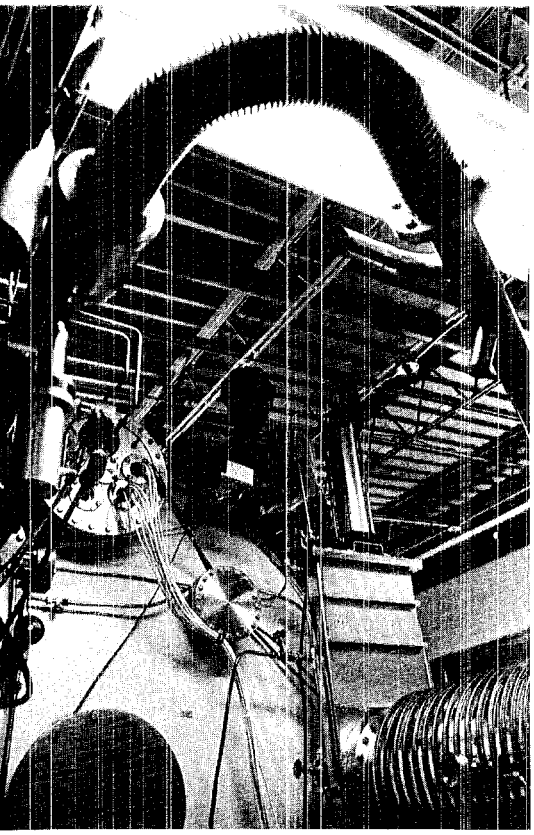
Karl Meier of Q-15 wants to test results of meteoroid damage on reactor parts, including the control drum, reflector, bearings, shaft, and actuator, all at 800 degrees Kelvin.

transportation system, will play a key part. "The chances are that both the development of an orbital enterprise system and the extended exploration of the solar system will demonstrate the need for expanded shuttle concepts," said Schmitt, alluding also to the possibility of establishing a moon base in the 1990s.

Reusable Shuttle

The Shuttle will be lifted into orbit by 2 reusable solid rocket boosters and 3 liquid rocket engines. Only the external tank, containing the liquid propellants for the orbiter's main engines, is discarded each flight. Once its space mission has been completed, the orbiter returns to earth, to be refurbished for another flight.

With the LDEF facility, experiment trays are being made available to scientific users who conceive, build, and mount their experiments. The trays are positioned around the near-cylindrical satellite on its 12 sides and on either end. Since LDEF will be in a gravity-gradient stabilized orbit, some experiments will be more able to draw power from the sun, or study its emissions, than will the "earth side" experiments. LDEF itself weighs about 8,000 pounds and can accommodate a 12,000-pound



To simulate the effects of a space environment on reactor parts, Karl Meier of Group Q-15 places components inside a large vacuum tank at Los Alamos. Heat pipe parts are subjected to high temperatures; the entire vacuum vessel is not.

The facility, 30 feet long and 14 feet wide, can carry a payload of 12,000 pounds. Space available for experiments is being taken up, said NASA, as preparations proceed for the first flight in 1981.

payload. Individual trays can contain power supplies in the form of lithium sulfur dioxide batteries for experiments that require energy to activate timers, open and close drawers, record data, and so forth. Some experimenters could also use solar cells to satisfy part of their power needs. LDEF is 14 feet across and 30 feet long.

At present, said NASA's Clark, 219 persons are listed as LDEF scientific investigators on 49 different experiments, and the numbers are increasing as LDEF space is taken up. The figures include representatives of 8 countries, and persons from universities, government, and industry.

The first Space Shuttle flight should occur in mid-1980, and the LDEF should be deployed from the Shuttle during a flight in late 1981. The second LDEF launch is scheduled for 1983. "Our concern is that it's safe to fly," said Clark. Once experiments have been built and placed in trays, NASA will run them through shakedown tests and ship them to Kennedy Space Center in Florida, the launch site for early LDEF missions.

In space, about 250 nautical miles above earth, the Shuttle will maneuver into a nose-down position. A remote manipulator system will remove LDEF from the Shuttle's payload bay and correctly orient it before the Shuttle moves away. Months later, LDEF will be retrieved from its orbit in a reverse fashion.

Reactor components

Karl Meier at Q-15, the space reactor group, would like to put several components in space on an early LDEF flight in January, 1982. He requires a tray about 33 inches by 49 inches by 12 inches. In it would be a mockup of a space reactor control drum and reflector, with bearings, shaft, and actuator.

At LASL, Meier's group is involved in the design of a reactor that could be used as a power supply for long space missions. Such a reactor would not be coming back to earth, and would be in fail-safe orbit at least 30,000 miles or more from earth. Space radar, Meier pointed out, requires up to 100 kilowatts of electrical power; propulsion requires up to 400 kilowatts. Solar panels, even with an array measuring 10,000 square feet or more, could not supply these amounts of energy.

Such a space reactor must carry shielding to protect onboard instruments from neutron and gamma radiation given off by the radioactive core. In space on LDEF, Meier wants to test results of meteoroid damage on the reactor parts, to see whether they would jam or deteriorate.

Control drums must turn during the 7-year lifetime of a space reactor, and they will be tested. Bearings that support the drums must not be subject to seizure. The actuator is an electric pulse motor that turns the control drums, and it must be proven reliable.

Meier said the experiment should be operated at 800 degrees Kelvin, to see if the components can stand up to extreme heat. A multi-foil insulation would keep up the temperature up, and reduce the required energy to sustain it. Solar panels could supply 40 watts of power, but Meier will need additional power from batteries for the experiment. They will turn the drum 32 degrees in 18 pulses, a sequence repeated once each hour for a one-year flight.

An emissivity coating test will also be placed on the tray, said Meier. It will consist of many titanium and beryllium plates with different coatings and surfaces, all made of potential space reactor radiator materials, those that carry excess heat from a deep space reactor.

"Space Garden"

Another Los Alamos proposal for LDEF is not from the Laboratory, but from Chamisa Elementary

"Creative use of the Shuttle will ultimately result in the humanization of space — that is the use of space for improvement of life on earth for all men."
— Maj. Joseph Angelo

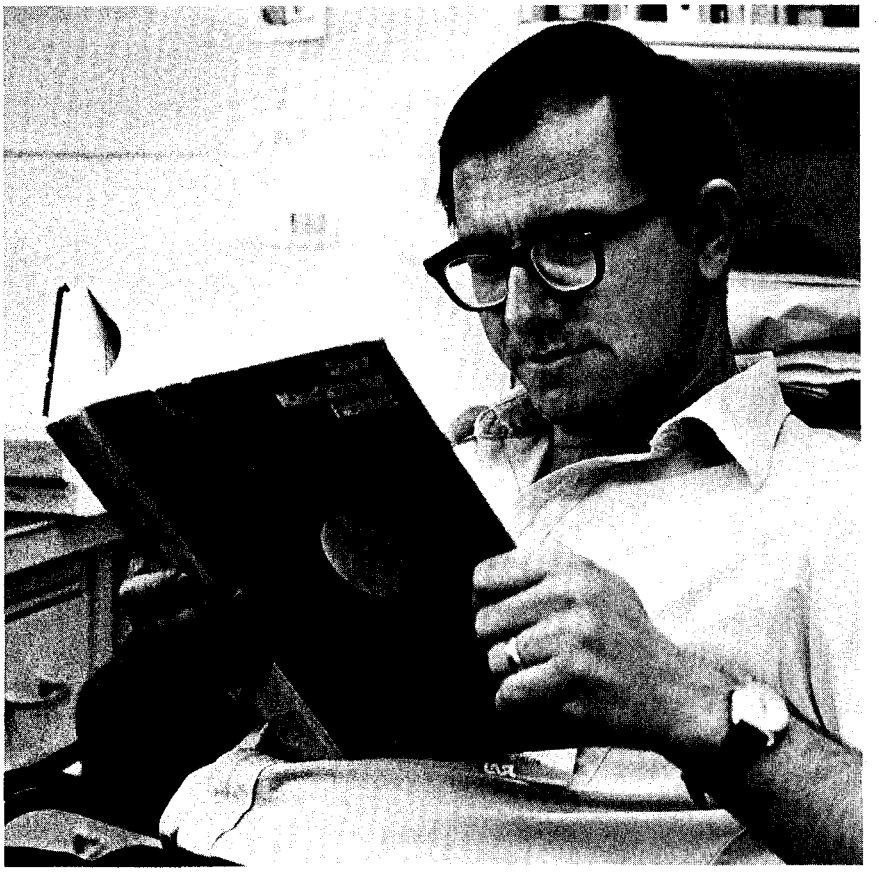
School, for which Maj. Angelo has arranged an experiment with the space agency.

Seeds will be flown on the craft in a small experiment, a few cubic centimeters in volume. They will be brought back to earth for planting in "Project Space Garden," and their performance will be judged against that of seeds from the same batches that are not taken into space. The mission is tentatively scheduled for the first LDEF flight. In the meantime, students will study aerospace science and technology as part of the educational project and will study which types of seeds should be used.

Teacher Jo Corrie said there are many possibilities to the project, and many decisions will be left to the students. "We would be silly to pass it up," she added.

Angelo himself is an avowed space technologist who holds a Ph.D. in nuclear engineering, and he has been working to connect persons he knows in astronautical circles with LASL researchers. He also hopes to develop an aerospace technology program with the local school district, which could become a Shuttle-era pilot program in the United States.

"We can learn technically from space, model the environment, do social planning," said Angelo. "New Mexico, if residents want it, could even become the center for laser or microwave transmission of power from space. Creative use of the Shuttle will ultimately result in the humanization of space — that is the use of space for improvement of life on earth for all men."



Maj. Joseph Angelo, a liaison officer with the Defense Nuclear Agency, invited NASA to Los Alamos to talk about Space Shuttle flights.

The first LDEF flight will tentatively be carrying "Project Space Garden," being carried out by Chamisa Elementary School. Here, students and teachers go over their plans.

Photo by LeRoy N. Sanchez

Our "shimmering, boiling limb" is diminishing: John Eddy.

'The sun is shrinking'

The sun is shrinking at the rate of 0.1 per cent each century, according to John A. Eddy, a visiting scientist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. He reviewed records from meridian transit telescopes in Greenwich, England, made from 1750 to 1954. Through such instruments, the solar disk appears as a "shimmering, boiling limb," he said.

The most reliable data from the 20th century points to a decrease of 1 to 2 seconds of arc per 100 years, said Eddy, in both the horizontal and vertical diameters. Through the years, however, other theories have been advanced, he told a colloquium audience.

One of them was by Hermann Ludwig Ferdinand von Helmholtz, a German scientist who in 1854 predicted the sun was falling inward. The potential energy of the larger size is transformed in to the kinetic energy of the shrinking, he said, contradicting the then-dominant theory of combustion. Helmholtz' ideas, however, only predicted another 3,000 years of life for our sun.

Later scientists, working with ever-better tools, said the earth was shrinking by one inch every day, but that would have the sun swallowing the earth, as one moved backward in time, with increasing solar diameters.

In 1920, the theory of nuclear generation in the sun was taken up, said Eddy, with a solar life prediction of several billion years. "We think the sun's diameter is a constant. But I remind you that is an assumption," he said.

Eddy then turned to the data from Greenwich, where in 1750 the first meridian transit telescope was installed. The instrument's axis became in 1884, by international agreement, the demarcation of the hemispheres, and is still used as that reference.

Such a telescope can swing up and down but not horizontally. It typically views the sky from a slit in the side of a building, and early observers lay on a couch below the eyepiece of the first 9-inch instrument. At noon, a "fuzzy sun" can be seen drifting through an arc.

The arc was measured and recorded, with only short interrupted periods, for more than 200 years, though not continuously with the same telescope. In an early "eye and ear" method, an observer would look at a clock just before the sun hit one of the grid crosshairs in the eyepiece, then record the tick-tock sound in his mind before marking the time of the sun's travels. Measurements of tenths of seconds were difficult with this technique, said Eddy, and a micrometer system was employed in the 1850s.

The Greenwich data show the sun's horizontal diameter is lessening by 2 arc seconds per century, and the vertical diameter by 1 arc second, said Eddy.

He mentioned an attempt by a remarkable group of 3 Italians, who in 1874 began tracking solar diameters on a 30-inch viewing screen. The same observers, incredibly, worked together until 1937, making notations daily in the interim. Of the data, said Eddy, "My inclination is to take them out."

Of his own conclusions of a shrinking sun, Eddy said the rate he presented cannot be permanent, or can't apply to the entire sun as a body, because if it did, the sun would have been 50 per cent larger for Cro-Magnon man 50,000 years ago than it is today. Nevertheless, he said, "The trend is for a smaller and smaller sun," a conclusion based on the Greenwich data and later readings from Washington, D.C. A serious ancillary question is whether this is due to a changing atmosphere around the earth, which could affect how the sun appears to us.

Eclipses are good measures of the sun's size, Eddy continued, when seen in historical contexts. On April 9, 1567, a "ring total" eclipse passed across Europe and was recorded by Clavius, the author of the Gregorian calendar and a Galileo colleague. This type of eclipse appears when when the moon is at its closest point to the earth, and all light is blacked out, and the stars appear. But in 1567, a faint ring of light remained.

Clavius also saw a ring total eclipse 6 years earlier, when he was in Portugal in 1560. That time, total darkness occurred.

The difference between the light remaining during these two eclipses, said Eddy, also tends to show that the sun is shrinking.

— JLP

Kerr reorganizes

A reorganization plan was made public August 3 by Director Donald M. Kerr, Jr., in his first week as the Laboratory's new top man.

In a press conference, Kerr, 40, said LASL's continuing major responsibility would be for the development and testing of nuclear weapons. Second, LASL will develop new approaches and technologies to assist in solving America's energy problems, he said.

He also listed 5 external factors that bear on the Laboratory. The movement from the old AEC to the new DOE has involved LASL in a wider range of research and outlook. The national security policy includes the questions of what weapons will be developed as well as various arms control initiatives. Limits to LASL growth have been imposed by the DOE. Congressional support must come from outside the New Mexico delegation as well as from our 4 Captitol Hill representatives. Finally, while the University of California voted 15-7-1 to continue managing LASL, other ways are being explored to strengthen that relationship, or to seek new arrangements.

In response to these conditions, explained Kerr, the Laboratory must establish priorities since it has limited resources appropriated by Congress. Planning and budget expertise must come into play. Organizational changes, he concluded, will give the Director and his staff better information to increase the Laboratory's effectiveness.

The majority of the technical staff members from the 19 divisions now existing will report to 3 Associate Directors under the new plan. The posts are distinguished largely by disciplines.

Robert N. Thorn, 54, is the Acting Associate Director for Physics and Mathematics. He also has been confirmed as Acting Deputy Director.

George A. Cowan, 59, is the Associate Director for Chemistry, Earth and Life Sciences.

Kaye D. Lathrop, 46, is the Associate Director for Engineering Sciences.

Kerr also named Richard D. Baker, 66, as Acting Associate Director for National Security Programs. This post will not oversee technical divisions directly, but will have a set of 6 program offices to handle the unique aspects of a weapons laboratory. There will also be a management support office.

Under Baker, William E. Deal, 56, will manage weapons research and development. Allan L. Conner, 45, will be in charge of pre-Phase I and beyond for the weapons program. John C. Hopkins, 46, will manage testing and verification. Inertial fusion will be under Roger B. Perkins, 43. William H. Chambers, 57, will manage safeguards and security. A Department of Defense manager is to be announced.

In another area, Rosemary Harris is the Associate Director for Administration and Charles I. Browne, 57, is the Associate Director for Support Services. A Controller is to be named, as is an Assistant Director for Planning and Analysis.

Frank C. Diluzio, 65, is the Assistant Director for Institutional Relations, and is to work with Kerr and the Public Affairs Department to define what resources are needed to handle the Laboratory's outreach programs.

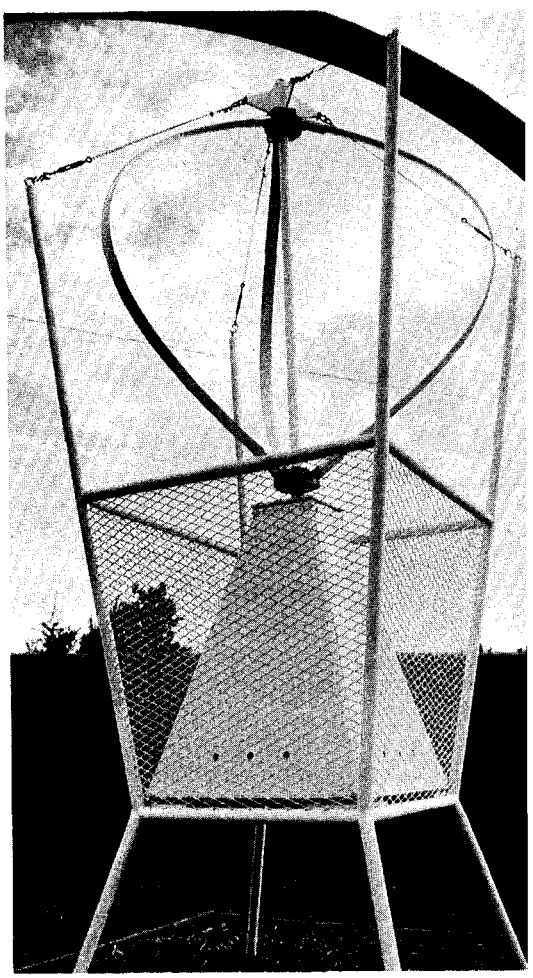
* * *

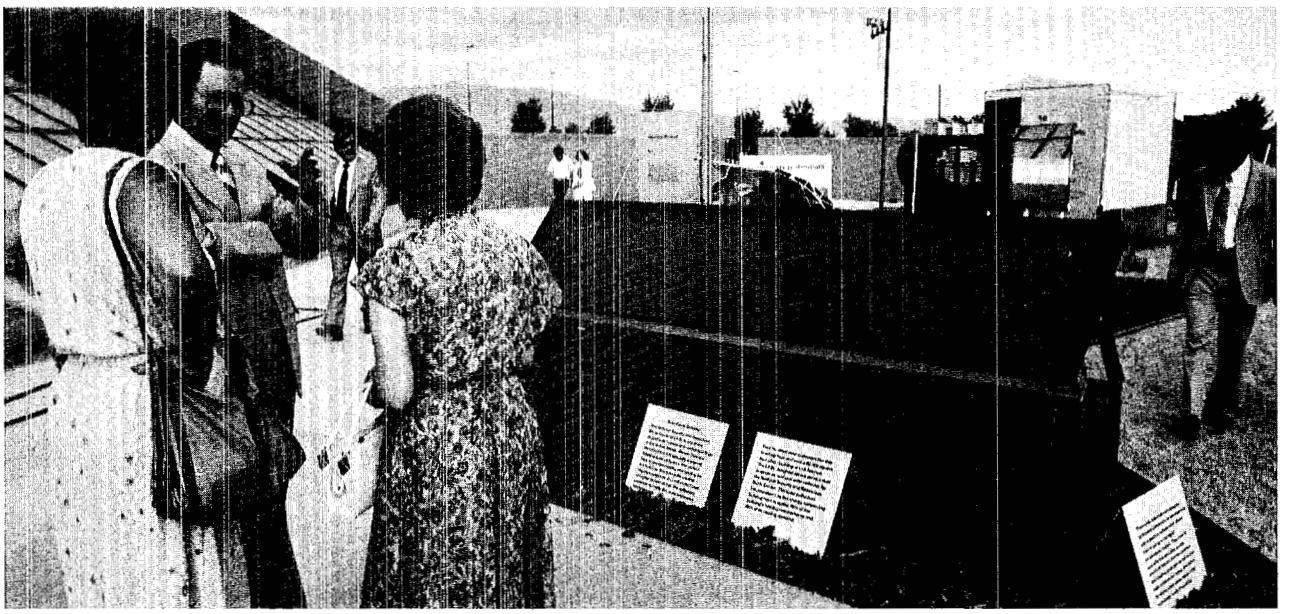
Patent awarded

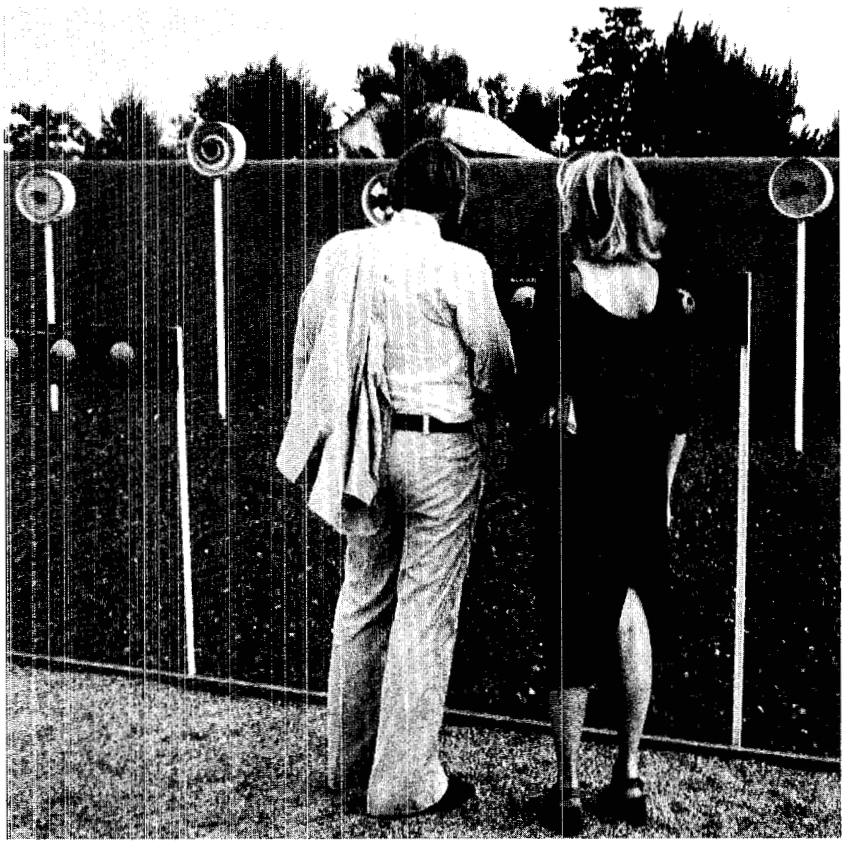
Patent 4,152,118 has been granted to Phillip G. Eller and Gregory J. Kubas of Los Alamos. The abstract states organophosphine copper mercaptide complexes are useful as convenient and semiquantitative visual sulfur dioxide gas indicators. The air-stable complexes form 1:1 adducts in the presence of low concentrations of sulfur dioxide gas, with an associated color change from nearly colorless to yellow-orange.

LASL on display

LASL, along with Sandia Laboratories, co-sponsored the opening science exhibit at the new $4.2 million Albuquerque Museum of Art, History, and Science. The outdoor exhibit is called "Probing Energy Potentials" and explains an array of advanced technologies in lay terms. Actual equipment, such as part of a vertical wind turbine, hot dry rock system, and solar power tower, is also on view. Topics also include fusion, fossil fuel recovery, and coal gasification. The expansive exhibit will be open for several months at the museum, located on Mountain Road next to Old Town in Albuquerque.

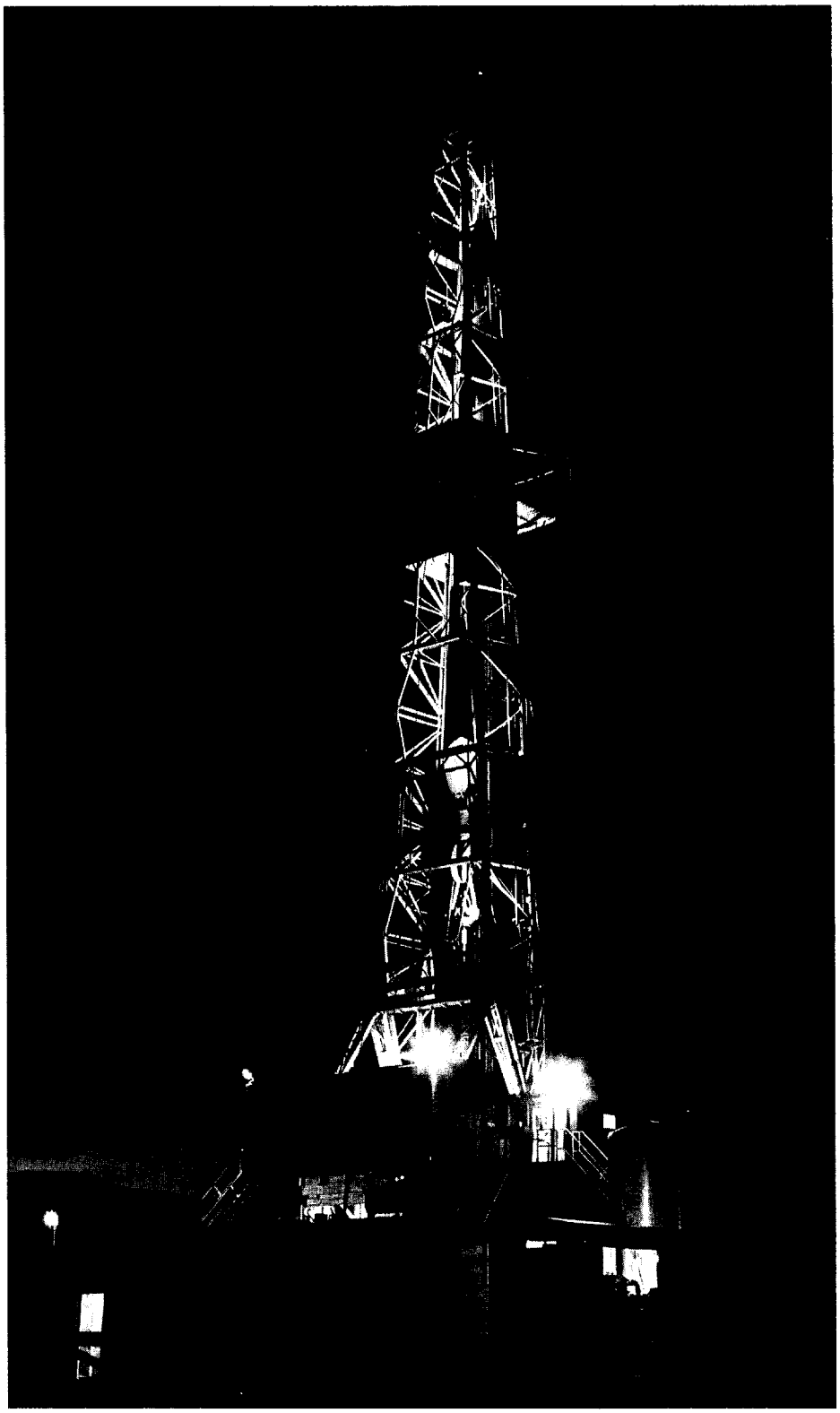






Photos by Jeff Pederson

At the Albuquerque Museum of Art patio, clockwise from the top: solar panel collectors; a shooting gallery with targets triggered by sunbeams; detail of a solar concentrator; and a vertical axis wind turbine model with one of the full size blades above.



Glow of the drill rig surpasses the sun after dusk on Sigma Mesa.

Photos by Bill Jack Rodgers

On Sigma Mesa, the drillers are...

By John Ahearne

LASL geoscientists are once again stoking what they call the "furnace at our feet" — this time, perhaps, to practice at home what they have been preaching from Fenton Hill for several successful years.

On Fenton Hill in the Jemez Mountains near Los Alamos, LASL researchers have proven the scientific feasibility of extracting energy, in the form of heat, from hot dry rock thousands of feet below the earth's surface.

In past experiments, 2 boreholes drilled to about 10,000 feet intersected a hydraulically fractured section of hot granite. Water was pumped down 1 hole, heated in the rock, brought up the second hole, and pumped back down the first in a closed loop. Heat was removed by an exchanger at the wellhead.

With the success of the Fenton Hill experiments, and some added impetus from the Department of Energy (DOE), the geothermal hot dry rock concept could evolve quickly from the scientist's notebook to a working, economical "turn on the thermostat and get warm" energy system — from "experiment" to an operational space and process heat source for laboratories and offices at LASL.

Toward this end, LASL geoscientists recently began drilling an exploratory well on Sigma Mesa east of the power plant to determine the local feasibility of hot dry rock energy, and, in fact, any other geothermal source of heat near the Laboratory's main technical area.

14,000-foot goal

The drilling crew intends to bore down to about 14,000 feet, and along the way hopes to encounter hot water, perhaps even steam, either of which could be useful for the project's purposes. In any event, geothermal energy of one form or another will likely be the heating

Looking for a new furnace

source for LASL in the decade to come.

The groundbreaking, or "spudding in," of the exploratory well was the first step toward compliance with DOE directives that call for future reduction, and perhaps elimination, of the use of natural gas by DOE facilities.

LASL is the largest user of natural gas in the DOE complex. All space heating is done with natural gas, and natural gas fuels the generation of emergency and peak-period electricity.

The decision to explore local geothermal possibilities was the result of an extensive study by scientists and administrators from LASL, DOE, and the Zia Company. The Task Group on Energy Sources, chaired by ENG-DO's Ed Sitzberger, was formed in mid-1977 to study the gamut of energy alternatives that might be compatible with the Laboratory's needs.

The 10-man task group members are Lon Alexander, ENG-4; Ronald Palmer, Q-13; Cecil Bingham, LAAO; W.H. Johnson, ALO; Paul Edwards, FMO; Lawrence Germain, G-DO; F.P. Schilling, WX-4; Robert Warner, MP-DO; and Thomas Cook, Zia Company.

The first job of the task group was the setting of criteria to be used as a basis for selection of the resources and methods that could be brought on line. The group outlined 4 objectives in the study, 3 of which are typical, and one that is patently LASL.

Demonstration value

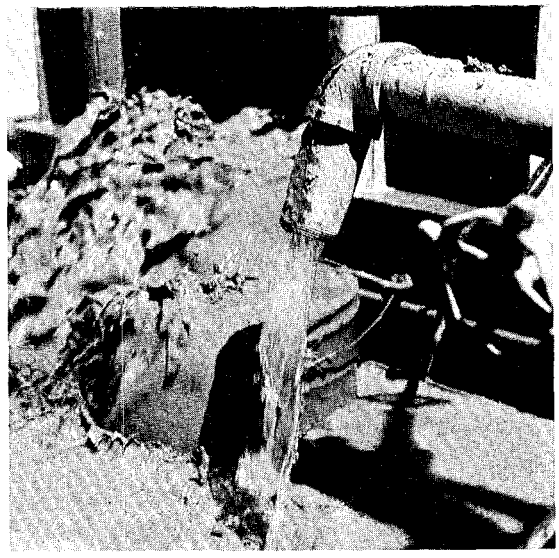
"Naturally we want a system of reasonable cost, that is environmentally acceptable, and that is compatible with the Laboratory's isolation and wide dispersement of sites," Sitzberger said.

"But because we are a leading energy research facility, we also hoped to suggest a system that would have some demonstration value for the country — a system whose economy and environmental acceptability are a result, to some degree, of LASL expertise," he added.

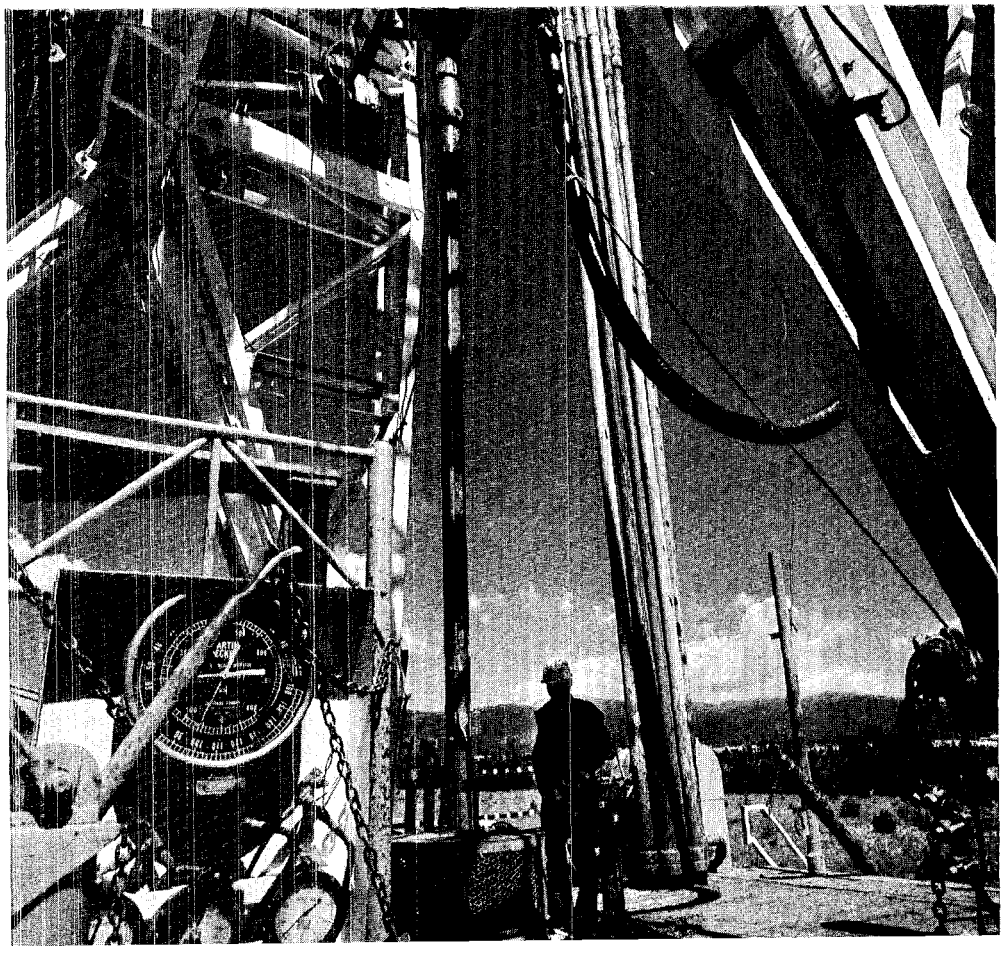
Next the task group compiled a list of possible energy sources to be considered. These included solid waste, wind, solar, wood, hydroelectric, nuclear, coal, and geothermal.

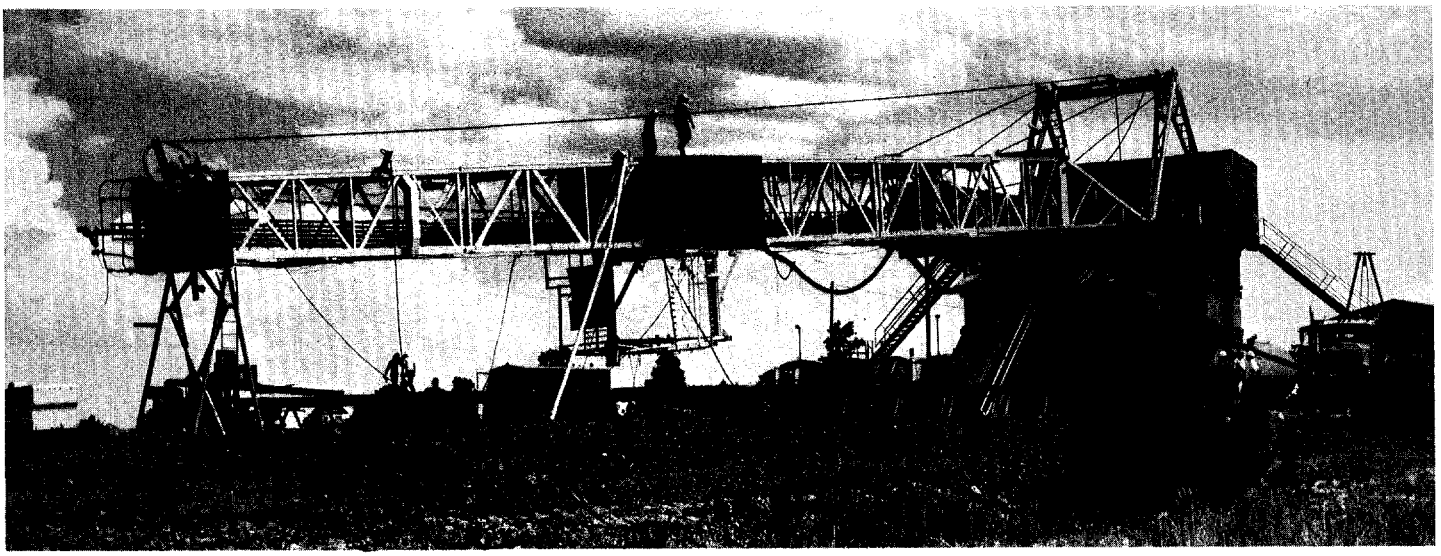
To have even more analytic capability, the LASL group hired an energy consulting firm, R.W. Beck of Denver, to assist in studying the wide range of alternatives.

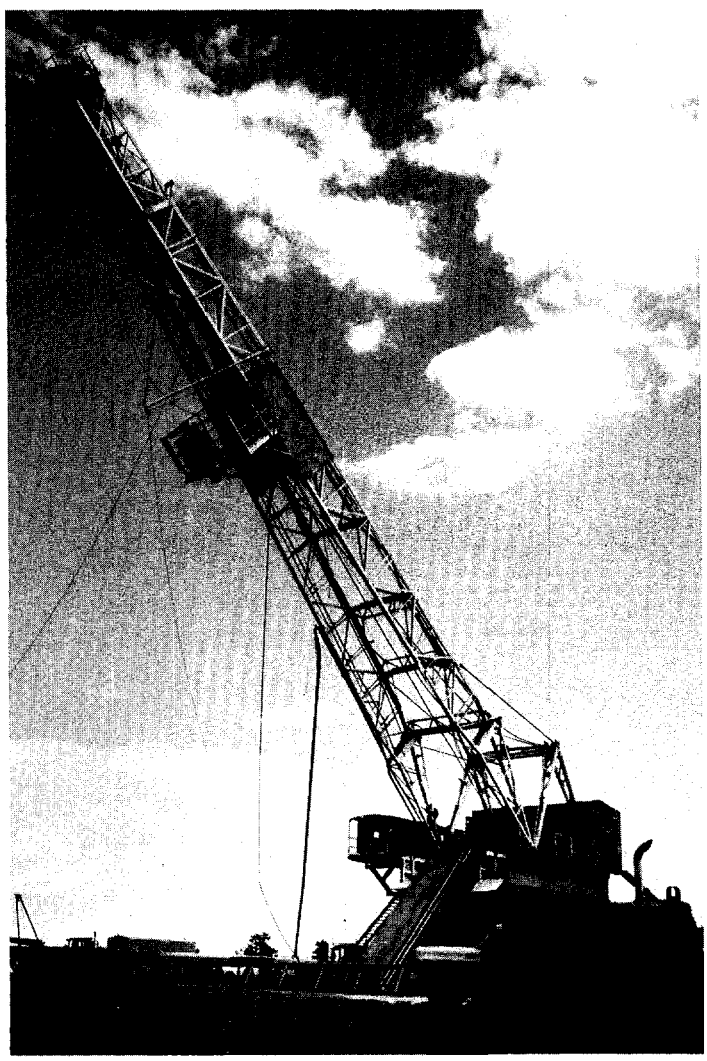
Beck established rating values which considered 9 factors to be applied to each of the energy sources on the group's list. The 9 factors were capital investment cost, annual cost, resource availability, resource consumption, environmental effects, schedule considera-

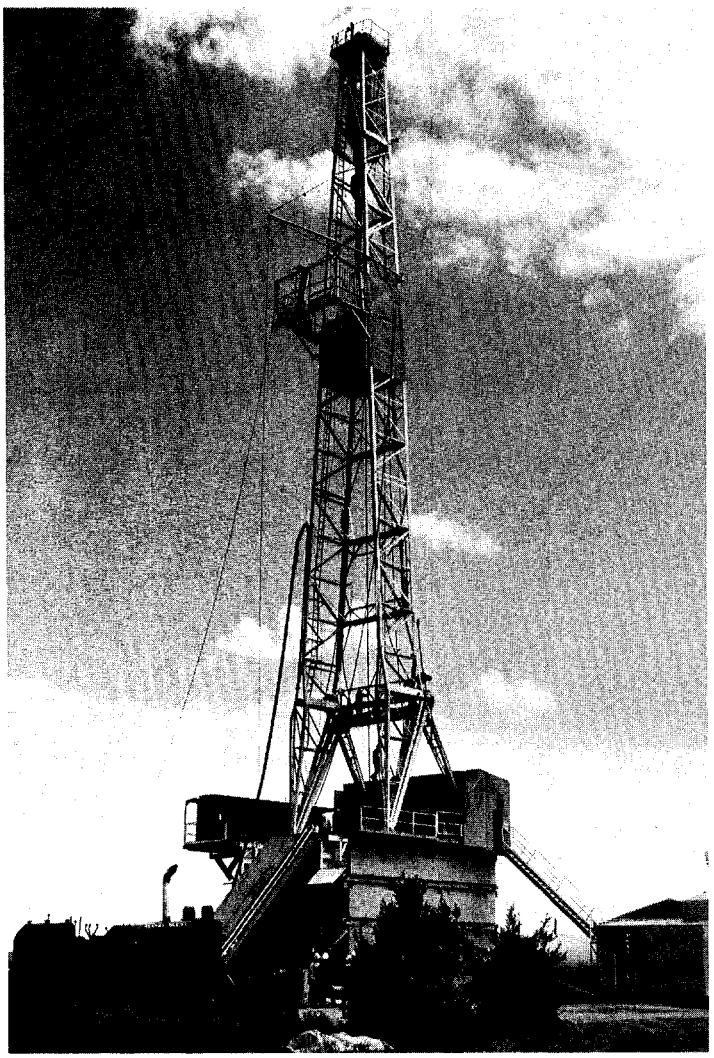


Mud and water, top, are used for lubrication as the drill bit goes down through rock. The view from the large rig's platform, bottom, includes the panoramic Jemez Mountains above Los Alamos for Jack Newsome of Moran Bros.



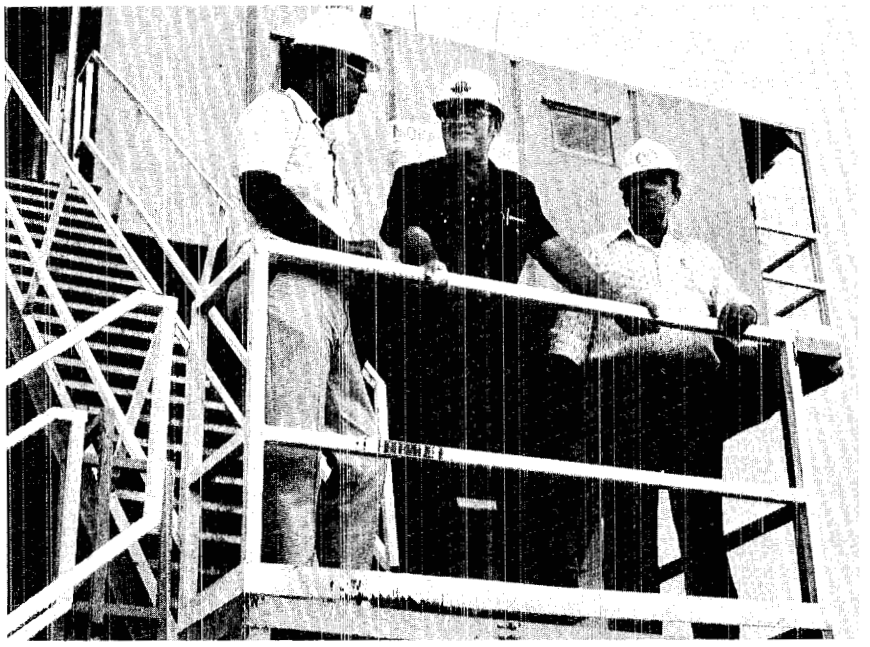






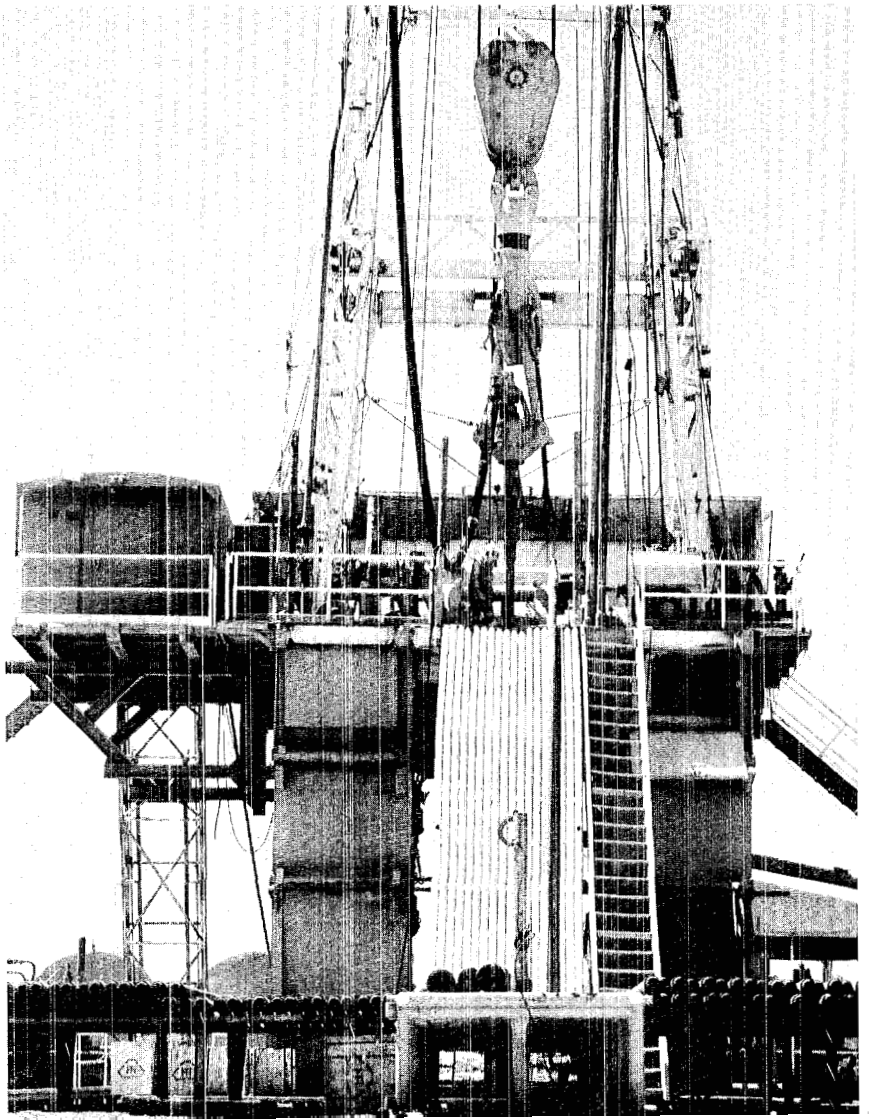
Photos by Tommy Velarde

Raising the mast of a drilling rig is not a light task. In this series from Sigma Mesa, Moran Bros., Inc. prepares its largest piece of equipment.



On-deck discussion involves (from left) Dick Olwin, LASL's project manager; J.C. Hicks, consultant from Hobbs; and Cliff Mankin, site boss for Moran Bros.

Pipe sections will be added as the bit descends.



Any hydrothermal source is likely to be found between 8,000 and 12,000 feet. Hot dry rock is expected below that level. The exploratory well should be completed by Christmas, and the energy system on line by the mid-1980s.

tions, availble technology, reliability, and demonstration value.

"Some of the resources we felt would be very desirable to use simply are not plentiful enough for Laboratory purposes," said Sitzberger. "For example, there is not enough consistent wind, and not enough water for hydroelectric or to sustain the large tree farm that would be necessary for a wood burning plant.

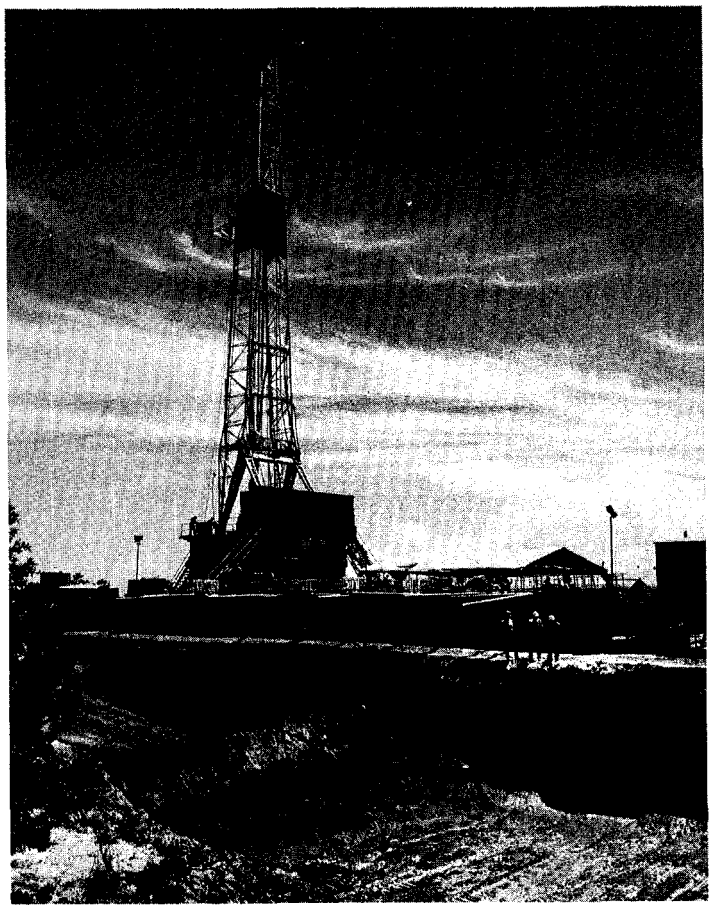
"Solar energy also fell short of our needs, particularly in winter months, and because we would need a complete and expensive backup system," he said. "We will, however, continue to consider solar systems in the design of any new buildings for the Laboratory.

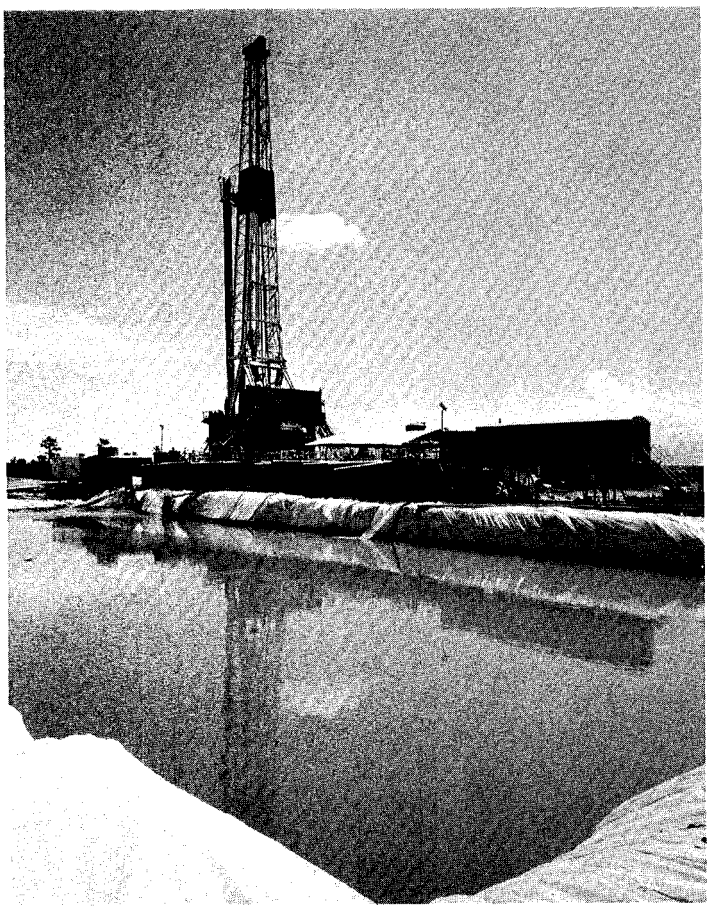
"Solid wastes generated in the county could only contribute about 5 per cent of the necessary energy, and, as in a wood burning system, there are pollution considerations that would add considerably to the cost," he added.

A final, short list

Following Beck's evaluation, the consultants and the task group generated a short list of remaining alternatives: A coal-fired central power plant, a goal gasification plant, a nuclear pebble bed reactor, and geothermal heating.

"Both plans that call for the use of coal were very reasonable in terms of cost," Sitzberger said. "But even with current technology, there





The site's pond, before and after a plastic liner and water have been added.

would be environmental effects which would be evident. Further, there would be problems getting the large amounts of coal to Los Alamos, what with the closest railroad line in Lamy (50 miles away)."

The pebble bed reactor will continue to be studied as an option. The pebble bed is a conceptually simple reactor type which uses relatively inexpensive ball-shaped fuel pellets.

Further, not only would this type of system be able to handle extensive energy loads, but it would provide a technological base — hence demonstration value — that does not exist for this type of reactor in the United States.

The reactor option, however, had one major drawback: capital investment costs of $129.2 million. That left geothermal heating.

A series of studies began to determine the optimum location for the exploratory well. The magnetism and gravity in the area were mapped out, and seismic soundings were taken to determine the topography of the rock structures beneath the Laboratory.

Further, the task group criteria called for a site that is near the main technical area (the main load center), in a spot where 3 to 4 acres of land are available, where water and electricity can easily be connected, and near favorable subsurface geologic structures.

By searching beneath Sigma Mesa, we may practice at home what we have been preaching from Fenton Hill for several successful years.

Sigma Mesa, near the existing power plant and the main technical area, was chosen. The Beck/task group study concluded that a series of wells in the area could, at a capital investment cost of less than $30 million, save from 40 to 60 per cent of natural gas used at LASL for heating the main technical area.

Only payback system

By taking over much of the space and process heating, and preheating of water used in electrical generation, the system would pay for itself in only 7 years. None of the other energy options studied would ever pay for themselves.

The $3.5 million exploratory well is scheduled for completion near the end of this calendar year, said site manager Dick Olwin. Upon completion, there will be a

testing and evaluation period before it can be determined if energy is sufficiently present for its planned use.

LASL has contracted Moran Bros., Inc. of Wichita Falls, Texas, to drill the projected 14,000-foot hole. The drillers expected to bore about 125 feet a day, beginning in early July, but have been slowed somewhat due to loss of downhole drilling fluid in some of the highly porous rock below the mesa.

"The well itself is 26 inches in diameter at the top, and will taper to just under 9 inches at the bottom," said Olwin. "That is large for an exploratory well, but if we find a source, we could use this borehole as part of the system."

Olwin said that any hydrothermal source would likely be found in saturated rock between 8,000 and 12,000 feet. Hot dry rock is expected to be found below the 12,000 foot level.

"The hot water we hope to find is not from the water table, or aquifer, which we think ends at about 4,000 feet," Olwin said. "The hydrothermal source is contained in an aggregate of material known as the Santa Fe Formation at least 4,000 feet below that."

If a sufficiently hot hydrothermal source is found, the hot water would be used to heat clean surface water to be circulated throughout TA-3. The water pumped from underground would be injected back in a second well.

Mid-1980s target

"Our current system of steam heating would be replaced by a high temperature water heating system that would circulate throughout the main technical area. If all goes well, the geothermal system could be on line by the mid-1980s," Olwin said.

Depending on the temperatures encountered, the configuration of the ultimate operational system would contain 1 or 2 well pairs for the limited use at TA-3.

If the project is successful, the system will have admirably met all the criteria deemed important by the task group, the DOE, and even a public concerned about polluting energy sources. The cost is reasonable, the resource abundant, effluents of any sort are minimal, and pioneering LASL research will have paid quick dividends to an energy-short world.

Greg Sherwood of Moran Bros. walked across the mud pit bridge at Sigma Mesa.

Drilling supplies are stacked at the site. Researchers hope the geothermal project will enable LASL to reduce its dependence on natural gas.

The geothermal option, concluded the task force, could pay for itself in only 7 years. None of the other realistic methods would ever do so.

Eklund reaffirms nuclear benefits

A man who has participated in the development of nuclear energy and who has "lived with and studied the effects of nuclear energy for more than 3 decades" recently reaffirmed his faith in its benefits before a LASL colloquium audience.

Sigvard Eklund, director general of the International Atomic Energy Agency, said the introduction of nuclear power into society has been handled well, indeed much better and far more carefully, than most other technologies.

"Man's inquiring mind has always tried to explore nature and make use of nature's resources," Eklund said. "It has learned to master nuclear power, which eventually promises a form of energy entirely independent of the limited resources of fuels in the Earth's crust. There will certainly be ups and downs with this new technology, but I am convinced that man will also master the problems to which nuclear power gives rise, and will not only continue but expand its use."

According to Eklund, the rapid worldwide rise in the use of energy has created a situation where nuclear energy must play an increasingly important role, both economically and socially, as a practical energy source.

"Between 1950 and 1975, the total family (non-industrial) energy consumption, worldwide, had 2 features," Eklund said. In that 25-year period there was an increase of 5 per cent annually, which led to more than a trebling of total energy consumption from 1.7 million tons oil equivalent to more than 6 million tons oil equivalent. A second significant feature can be found in the substitution of liquid hydrocarbons for coal as fuel.

"Hydrocarbons furnished almost two-thirds of the total energy supply for this time period," Eklund said. "It seems unavoidable that the growth of world energy demand will continue over the next decade, although the rate of growth will certainly be different than those witnessed in the past."

This increase will take place despite conservation because of a general increase in the world's population, especially in developing countries. Economic increases in developing countries and a time lag inherent in the implementation of energy conservation measures in industrialized countries are also contributors to energy growth, Eklund added. Development of less populated areas and a general increase in the use of foreign mineral ores and of mineral waste recycling have added to increased energy usage.

"The world's population is expected to rise by 50 per cent from 4.1 billion to 6.5 billion at the end of the century," Eklund said. "At the same time, the share of the developing countries will increase to more than 5 billion from 72 per cent to 78 per cent."

He added that this is particularly significant because the initial stages of industrial development are particularly energy intensive.

"Even if highly industrialized countries were to hold (energy increases) to zero," said Eklund, "the emergence of developing countries would mean significant increases (in consumption)."

He added that lifestyles and social infrastructures don't change overnight, which would negate the near-term impact of conservation programs.

Eklund quoted a review by the World General Conference on Nuclear Energy (Salzburg, Austria, 1977) which concluded that the present yearly energy demand of 6.7 billion tons of oil equivalent is expected to rise to 12-15 billion tons by the year 2000.

"This means that the cumulative world energy use will be on the order of about 250 billion tons of oil equivalent over the next 22 years," Eklund said. "For oil to maintain its share of the market would require a cumulative production of more than 110 billion tons where its present proven reserves are only 90 billion tons."

He allowed that more petroleum discoveries are bound to be made, but that these new discoveries could only postpone for a few decades the unavoidable ultimate exhaustion. He said a similar situation exists for natural gas and coal because of uneven distribution and serious environmental and social problems. These energy sources could only partially fill the widening gap of the progressing depletion of oil and gas reserves.

Eklund emphasized that renewable sources of energy must be developed, but "hydroelectric is already heavily exploited, and solar and wind are available in only diffuse or irregular forms." He said the combined share of the 3 is unlikely to exceed 10 per cent of the total by the year 2000.

"On the other hand," Eklund said, "nuclear power technology is ripe for immediate and expanded contributions." He said 4 things must be explored along with nuclear development. These include the present status of nuclear energy, its economic competitiveness, obstacles to its expansion, and actions required to overcome these obstacles.

According to Eklund, the United States is lagging behind in the use of nuclear power. He said this country obtains about 11 per cent of its power from nuclear plants, while such countries as Sweden, Belgium, and Switzerland receive 22, 22, and 17 per cent (respectively) of their power from nuclear plants. He added that some developing countries boast a reliance on nuclear power. India receives about 2 per cent of its power from nuclear plants and South Korea about 14 per cent. He predicted that by 1985 his home country, Sweden, should be about 40 per cent nuclear pow-

Photo by LeRoy N. Sanchez

LASL's Deputy Director Robert Thorn (left) spoke with Sigvard Eklund (right), who heads the International Atomic Energy Agency. Man's mind, said Eklund, "has learned to master nuclear power and make use of nature's resources."

ered. He said that these facts indicate that nuclear power has exhibited a substantial competitive edge over oil-fired stations.

Eklund said existing estimated and proven reserves of uranium should provide power under maximum conditions up to the year 2000. Commercial breeder reactor technology could extend these projections almost indefinitely. He added that the cost of uranium would probably not rise faster than the cost of oil.

"Why, then, have reductions in nuclear power occurred, as compared with our 1973 objectives, against a 5-fold increase in the cost of oil?" Eklund asked.

He said a prime reason is "we are now faced with the so-called public acceptance issue where rational arguments no longer carry weight." He said that groups against nuclear technology are not apparent in socialist or developing countries, but have grown out of the industrialization of the western world.

"They (anti-nuclear groups) probably have their roots in the dissatisfaction of a growing number of young people in countries where a secure economic life is guaranteed from cradle to grave," Eklund said. "The anti-technology character (of these groups) appears in other sectors of modern society, and with the help of mass media the movement can exercise an influence out of proportion to the number of its supporters."

Eklund credited anti-nuclear groups with being at least partially responsible for bringing about new technology in the fields of waste disposal and safeguards.

"There are environmental concerns," he said. "This is not the place to discuss such concerns, but it is necessary to compare (nuclear technology) with alternate energy sources.

"These effects should be compared to the risks involved with natural events, which we take for granted, and manmade risks, which we accept as part of life in our industrialized society," Eklund said.

He briefly addressed the proliferation problem by saying that although the peaceful uses of nuclear technology have grown considerably worldwide, there are only 6 countries that have developed a nuclear weapons capability.

Eklund said that between 1945-54, 3 countries developed nuclear weapons. Between 1955-64 the number of countries with nuclear weapons grew by 2. Between 1965-74 only 1 country proceeded with nuclear weapons development. Eklund said that in the last 5 years there have been no new entrants to the nuclear arms race.

Eklund became the second director general of the International Atomic Energy Agency in December, 1961. Under his direction the agency has grown from a fledgling offshoot of the United Nations to its present size consisting of 1,400 staff members representing 110 nations. Eklund's host Robert Keepin, director of nuclear safeguards programs at the Laboratory, said the agency has an $80 million yearly budget. Of this figure, $20 million is devoted to safeguarding special nuclear materials.

"(The Agency) has the responsibility for assuring safeguards ability of the special nuclear materials in some 500 facilities around the world," Keepin said. "It is indeed a bargain price for such a gargantuan task."

— Vic Hogsett

10, 15, 20 years ago

20 years ago

Ashley Pond rejuvenation

The Atomic Energy Commission has taken the first step toward fixing up Ashley Pond downtown. Most of the water — more than 700,000 gallons — has been pumped out. Now the bottom will be smoothed and rubble collected from a sump in the center. The next step will be removal of large rocks around the pond edge. It's unknown now whether a sloping, sandy shoreline is in the offing, or whether the fence will be taken out.

Looking for moon clues

Meteorites may hold the key to the moon's composition and to the radioactivity the first moon walker can encounter, according to E.C. Anderson and M.A. Van Dilla of H-4. They are studying the gamma ray spectra of meteorites to help interpret data they hope to receive from the moon itself in 1962, from a Vega IV rocket. Close examination of photographs seems to demonstrate a theory that the moon was created at cold temperatures from cosmic dust particles in space and never heated — that would indicate the moon's gamma ray spectra should look like those of meteorites.

A bumper crop

The country swarms with squirreling people shaking branches, and hard, tiny, cocoa-colored pebbles come pelting down. The harvest of pinon nuts is reportedly the largest in the state since 1936. Santa Clara Pueblo Indians prepare them by the 100-pound bag, roasting the nuts overnight in outdoor ovens and removing them just before sunrise. Hilltoppers are more likely to use cookie sheets in ovens set at 400 degrees F.

15 years ago

Booming construction

Concrete pillars jut skyward as the new Administration Building takes form at LASL, one of many projects wherein the Atomic Energy Commission is spending $13 million this year on the town and the Laboratory. One impressive site is the high school, which is receiving a new auditorium, a practical arts building, a home economics cottage, and enlarged commercial courses buildings and cafeteria. Other projects include upgrading of Diamond Drive and a million-gallon water tank on Guaje Canyon Road.

The bird bows out

Nine years of research and 5 years of testing came to fulfillment August 28 when the Kiwi-B4-E reactor, from all indications, turned in a dazzling performance at Jackass Flats, Nevada. The eighth and final test operated for more than 8 minutes at close to the design power of 1,000 megawatts. This gives natural impetus to Project Rover, the nation's program to develop a nuclear rocket. LASL's Kiwi program began in 1955.

A venerable church

Although the church at Ranchos de Taos is one of the last established by the Franciscans in the Southwest, it is the oldest unrestored church in the area and has been continuously used since 1772. The building was designed in Spain in the early 1700s; construction with native adobe and beams took half a century. Starting in the early 1600s, the Franciscans established over 200 years some 49 churches in New Mexico, 21 in California, 20 in Texas, and 18 in Arizona.

10 years ago

New x-ray source

Instruments aboard the Vela Satellites 9 and 10 have detected the birth of a new x-ray source in the southern sky, near the boundary between the constellations Centaurus and Lupus. LASL staff members, who are responsible for the Vela program with Sandia Corporation, notified the International Astronomical Union of the discovery. About 40 x-ray sources have been found in the last several years; none of them have emitted such intense radiation (3 to 12 keV).

Mapping the tongue

Prospects are good that inroads will be made in the area of speech defects, under a program between LASL and the University of New Mexico to map the movements of the human tongue. An artificial palate with 48 sensors is placed against the roof of the mouth. A computer takes readings of each sensor 100 times per second, recording patterns in the mouth. Voice prints can then be made and studied.

To a post in Austria

Glen Graves, assistant N-2 group leader, has been appointed head of the physics section, research and laboratories division, of the International Atomic Energy Agency. He will be on an 18-month leave in Vienna. The IAEA seeks to further atomic energy uses for world peace and prosperity, and to assure that its assistance is not used for military purposes.

Compiled from past issues of *The Atom* and *LASL Community News*.

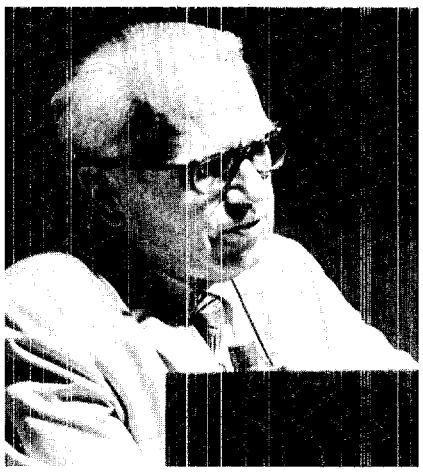


Photo by John Flower

Gerhard Herzberg, a Canadian physicist who won the Nobel Prize in chemistry in 1971, conferred with scientists here on studies of heavy hydrogen molecules, a specialization of the German-born researcher. He also presented a theoretical colloquium during his stay.

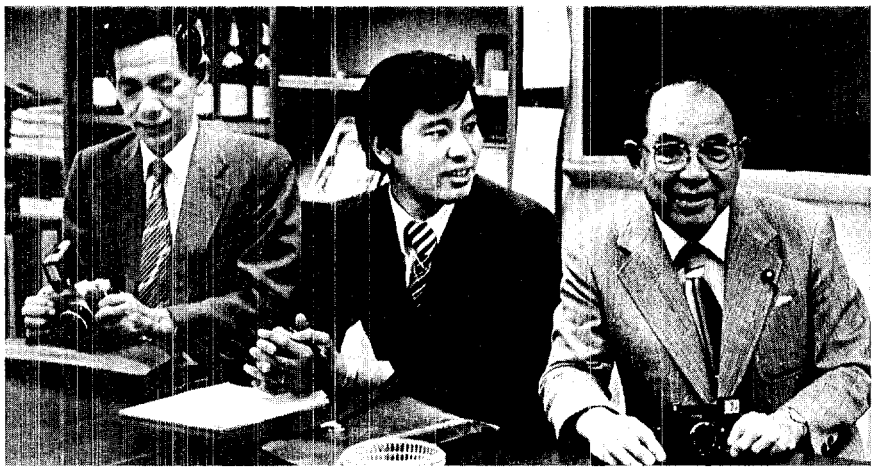


Photo by LeRoy N. Sanchez

Three visitors from Japan came for a day-long agenda recently. They are Susumu Haniuda, Parliamentary Vice-Minister for Science and Technology in the Prime Minister's Office; Chihiro Izawa, Science Counselor, Science and Technology Agency; and Tsuguhiko Katagi, Sacramento Office, National Space Development Agency of Japan.

Among our visitors

Eleanore Linsmayer, the German Consul General for the south central states since August 1978, heard about inertial confinement from John McHale, PUB-2. Linsmayer holds a law degree and was formerly with the German mission to the United Nations.

Photo by John Flower

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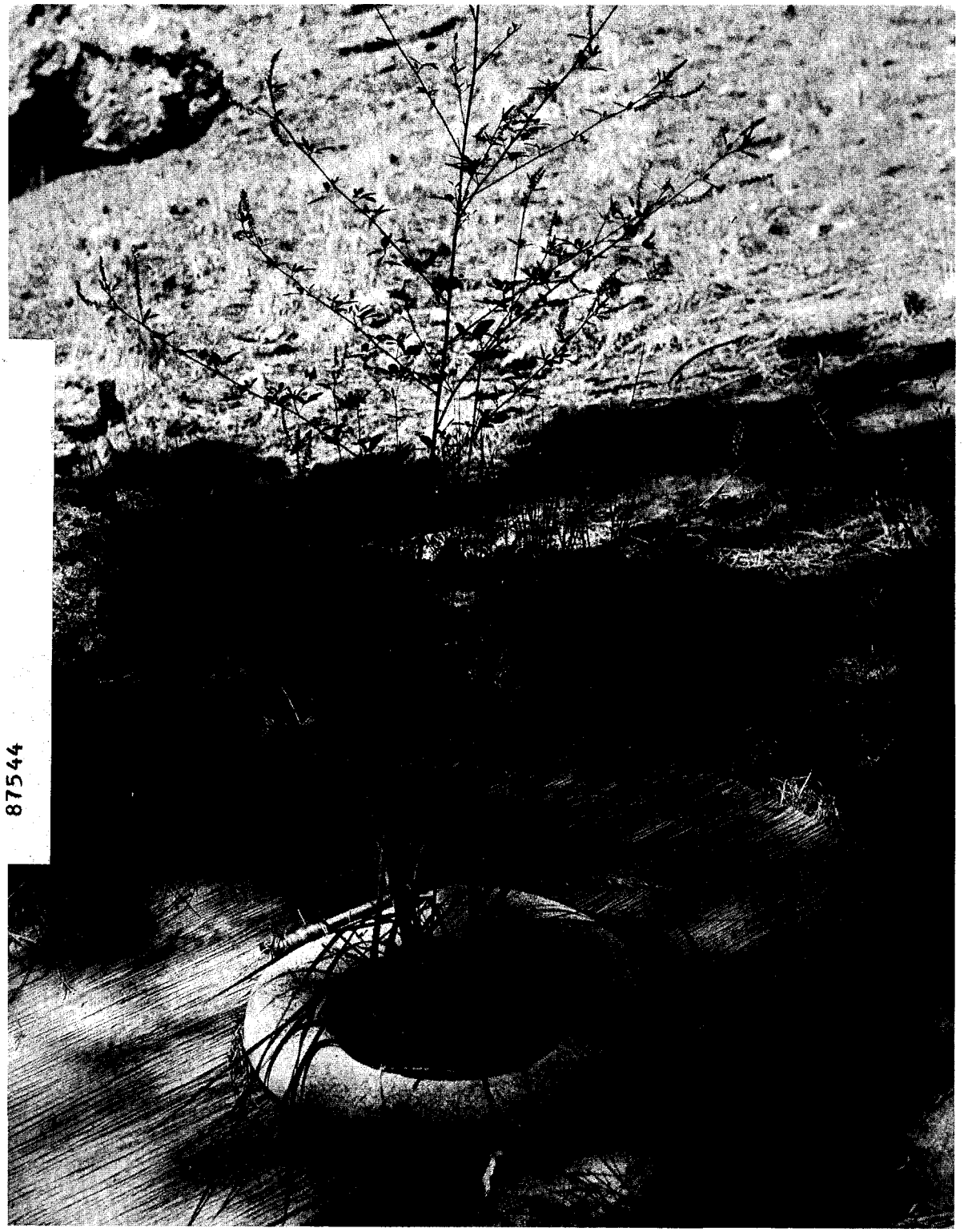

The composition called "Flower Pot" was photographed at a former Girl Scout camp off Trinity Drive near downtown Los Alamos by Bill Jack Rodgers.